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A longitudinal study
investigating pupil attitudes towards
their school science learning experiences
from a gender perspective

A thesis submitted in fulfilment of the requirements of the
Open University for the degree of Doctor of Philosophy.

Science Education

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Abstract

The research aim was to challenge the belief that girls' access to and performance in science education is *no longer problematic based on evidence of the continuing low uptake by girls of science courses post 16 and female participation in science related careers*. The research hypothesised that affective factors were influential in this and explored through a longitudinal study how girls and boys experienced science in Key Stages 3 and 4.

The initial literature review examined research into the relationships between attitudes and gender and the conceptualisation of these constructs. The study drew on this to survey 208 Year 7 and 8 pupils from three community schools about their views of their self-efficacy as science learners, their topic preferences and interests in science. A sub-sample of twenty pupils from each school was interviewed annually through to Year 9 to probe their perceptions of what influenced their experiences and affected their learning.

The data revealed that looking for some concept or construct of attitudes to explain science achievement was not productive to understand either achievement or how pupils feel positioned in relation to science. The second phase of the research, based on a social view of learning and knowledge, *focused on 20 case studies of a sub-sample of pupils from one school as they studied science in years 10 and 11. Narrative accounts were derived to show how individuals react to common experiences in science and how this impacts their achievements and liking for science and their future engagement with it. This approach provides insights into attitudes as personal responses to lived experiences in school science and a more subtle view of gender mediation that emerges first from individual experiences out to common influences to reveal that there are no simple relationships between achievement, liking for and engagement in science.*

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Introduction and background to the thesis

Historically there have been differences between girls and boys in the achievement and uptake of science, particularly the physical sciences. This has been the case both in the UK and worldwide. Educationalists became concerned about what appeared to be a major failure within the education system in the UK. The reasons for some of these differences were explored and researched extensively in the 1960s and 1970s.

Evidence from this research (before the introduction of the National Curriculum in 1989) suggested that some of the reasons were associated with:

- different interest levels with boys preferring physical science and girls preferring biological science,
- the relevance to pupils of the topics introduced in science,
- the existence of a 'hidden' curriculum acting to dissuade girls from studying a subject purported to be more suitable for boys,
- stereotypical images of science portraying the subject as masculine.

During this period girls were underachieving compared with boys and many girls were not opting for physical science at age 14+. *Few girls were taking any sciences apart from biology in the sixth form (age 16+).* It was felt that if girls changed their attitudes towards science, there would be an automatic reduction of the girls and science problem. There was also a concern about the numbers of scientists and engineers for future research and development, and girls were thought to be an 'untapped resource' that could help to meet the shortfall in these numbers. In the post National Curriculum period, *girls were participating and achieving equally, if not better, than boys in terms of number of examination entries and passes in science at GCSE level (DfEE, 1989-1997).* Despite various interventions, some of which were gender related, and others that were related to curriculum development and changes in teaching and learning strategies, there were still concerns

about the numbers of pupils, particularly girls, taking physical sciences post-16 (Osborne, Driver and Simon, 1998).

The research in this thesis originated from my experience of over 20 years teaching and working within science education. I had always been interested in the different ways in which pupils experience school science learning. I was aware of the general dip in interest that commonly occurred between Years 8 and 9 and was interested in the research undertaken in the 1970s and 1980s concerning girls and physical science uptake and achievement. *I was particularly aware of the gender disparities in the uptake of science courses after the compulsory period of science education (at age 14 years pre 1989 and after 16 years post 1989).*

During this time I became involved with many curriculum development projects, for example, a Sci-Tech course (in which pupils studied separate sciences with electronics for four General Certificate in Secondary Education (GCSE) awards. The course involved the development of cross-curricular materials with the Technology department and also project-based study). Shortly after this I left full-time school science teaching feeling rather disillusioned that these trends in uptake and achievement in school science were continuing.

Whilst taking a break from school teaching I became involved with the development of a community project working with adult women and science. The Women in Science (WS) course for adult women was a broadly based science course with no clearly defined vocational purpose and was a rare example of a course designed for women and taught by women. The main aims of this course were to reduce women's fears of science and to help them recognise what they already knew about science (Barr, 1990). This experience demonstrated, both to the women participants and the tutors, that science education could be a positive, collaborative and rewarding experience for all involved. The women participants had all rejected science at school for a variety of reasons including the masculine image of science, the abstract nature of school science and the inherent difficulty of science. An evaluation of the WS course concluded:

...one way in which the women's perceptions have been changed by the course is to admit more of the everyday aspects into the category of what counts as science. The arcane world of the laboratory bench is replaced with 'the world around us'. (Barr, 1990, p131.)

One woman suggested that before embarking on the WS course:

...it (science) was test tubes and mad scientists; at school physics was above my head. *Here, it's areas that affect you. I didn't realise that pollution came under science...and everyday things like cooking. I just think that everything is scientific now...* (Barr, 1990, p131.)

During this time I completed a Master's degree that incorporated modules on gender and education, and curriculum and learning. This degree focused my thinking and provided me with a theoretical framework for my experiential understanding of issues associated with equity, teaching, learning and assessment processes and curriculum development within education. I studied the Assessment of Performance Unit surveys on whole populations of school pupils and began to understand that some of the reasons for differences in performance were associated with pupils' attitudes. I had never related my understanding of pupils' attitudes to and performance in school science to biological differences between the sexes, but believed, like the research field at the time, that these differences had arisen because of external influences. I understood from my school teaching experience and my work with the WS project that there were factors affecting learning within the classroom that could be changed to improve learning experiences for students and pupils. Talking with the WS students and with pupils in school further developed my awareness of some of these negative influences on their learning, for example uninteresting and seemingly irrelevant content, formal and didactic teaching style, too much passive learning (writing, listening to the teacher), etc. I later began teaching science to university foundation course students and found that many of these students had experienced similar difficulties with their school science experiences as the WS students reported. Simultaneously I began tutoring Post Graduate Certificate in Education (PGCE) students. The MA studies resonated with my own professional experiences and made me want to consider issues and collect evidence about influential factors in the teaching and learning environment.

Following these experiences I started the present research in 1993 in order to explore some of my concerns over the compulsory part of secondary schooling in science. I chose secondary school pupils, *as this was the age group of which I had most professional experience and because my knowledge of the research at this time suggested that it would be a fruitful area to explore.* At the beginning of this research I had recent experience of teaching secondary school science and I felt sure that my background experiences in school and other science education arenas would enable me to explore the ways in which girls and boys experienced their school science learning from a well-informed perspective. *I believed that one of the major reasons for girls not taking up science at post-16 rested with poor or negative attitudes towards their school science learning experiences.*

Chapter 1 The research context

1.1 Towards an understanding of the problem

1.1.1 Introduction

In this Chapter I review the position of women in science in the UK. Manthorpe (1985) wrote about this position and argued that the girls and science problem, as it was first identified (by for example: Ormerod, Bottomley, Keys and Wood, 1979; Kelly, 1981; Hadden and Johnstone, 1983; Girls and Science and Technology (GASAT) conference proceedings, 1981-1985), was thought to be one brought on by the girls themselves, as it was they who held negative attitudes about physical sciences. In 1993 when I was beginning my research there was a controversy about the way in which measured gender differences in performance were understood and this continues to the present day. The controversy was concerned with the identification of the main sources of influence on gender differences in performance, and in the 1970s and 1980s this was thought to be associated with pupils' attitudes towards school science. In order to explore both attitude and performance issues, a number of national and international surveys were carried out in the UK and the US in the 1980s and in this section I have selected some major surveys as well as a localized English project to illustrate some of the ways in which the issues associated with girls and science have been researched. These surveys were established to attempt to interpret the reasons for measured gender differences.

The Government's Assessment of Performance Unit (APU) conducted national surveys (between 1980 and 1984) of attitudes towards science with populations of 11, 13 and 15 year old pupils from schools in England, Wales and Northern Ireland as part of its survey of science performance (DES, 1988a, 1989a and b). The attitude differences were thought by some to be caused by innate differences between boys and girls but others believed that the development of attitudes was influenced by social forces¹. The APU Science at age 13 (DES, 1989b) assessed pupils' liking of

¹ Social forces include environmental factors related to socio-cultural and psycho-social effects.

various aspects of science and whilst they argued that this measure was not to be claimed as an absolute measurement of attitude to school science, it would have some relevance in that area. *Pupils do become more engaged in activities they enjoy and effective learning is therefore more likely to take place.* Responses to APU attitudinal questionnaires showed differences across the age groups - boys' interests inclined towards physics and technological applications and girls' interests lay in biological and medical applications (Johnson and Murphy, 1986). The reasons for some of these differences were associated with pupils' views about areas of content where they felt more or less competent and this was related to gender domains, i.e. those areas of experience associated with one or other gender (Browne and Ross, 1991). This was exemplified by questions assessing subjects with an electrical content where girls anticipated failure more than boys and consequently performed less well overall as more girls than boys failed to respond.

The Girls into Science and Technology (GIST) intervention (1980 to 1983) in the UK hypothesized that female under-achievement in science and technology was partly socially constructed by the school, based on evidence reported by Kelly (1981). The project included a range of tests, including three attitude tests (Science Curiosity, Scientific Activities and Image of Science). These were given to pupils in their first term of secondary school (age 11 years), with tests being repeated two years later. The Science Curiosity tests were designed to assess initial motivation by asking pupils to respond to a variety of KS3 topics in three categories: 'I'd like to know more', 'not sure' or 'not interested'. Pupils responded very positively and enthusiastically about learning science and girls in particular were keen to know more about nature, medical science and the environment. The Science Activities survey (a 42-point Likert-type questionnaire) was used to assess participation in out-of-school science activities as these were considered to affect performance in school science (Johnson and Murphy, 1986). The Images of Science questionnaires were used to assess pupils' stereotypes of science and scientists, as well as their personal interest in science and their views on the social consequences of science. The outcomes of the project have been fully described elsewhere (Smail. et al., 1982; Kelly, Whyte and Smail, 1984). Briefly the project findings indicated that girls' attitudes to science became more positive in the action schools but this

did not alter their subject uptake in favour of science. In general, pupils' attitudes to science became more negative as they went through secondary school. The project shifted its focus away from locating the issue as one of girls' motivation, towards attempting to change the nature of science in school.

At a similar time in the US, the National Assessment of Educational Progress incorporated a substantial number of attitudinal items, looking at relationships between teachers and students, types of teaching strategies and students' feelings of adequacy in science (NAEP, 1976-1977, 1981-1982, and 1985-1986). The student samples were aged 9, 13 and 17 year old. These surveys documented a decline in pupils' attitude towards science from earlier to later grades. The International Assessment of Educational Progress (IAEP) survey results for science found a similar decline (Keys and Foxman, 1989). The First Science Study of the International Association for the Evaluation of Educational Achievement in 1970 (IEA) found that boys had more positive attitudes towards science and were more interested in science-related activities than girls (Comber and Keeves, 1973). The survey found that gender differences between 10 year olds were comparatively small but increased significantly with age.

The findings of these national and international surveys can be interpreted as reflecting that the problem with girls and science was being caused by the girls themselves. The GIST project team did eventually suggest that the problems associated with girls and science may be located with the way in which science is presented in schools. In the next section I explore whether these attitude differences arose as a result of innate differences between the sexes or whether there were other factors influencing these attitudinal variations. These variations can be interpreted as indicating something about girls, something about science or an interaction between them. In order to do this I investigate the gender research at the time.

1.1.2 Gender research

This section explores research carried out as early as the 19th century, but mainly during the 1960s to the early 1990s, to explore some of the explanations given for gender differences in cognitive ability. This is a key issue for my research because I want to establish whether there are innate reasons to explain the different levels of performance of girls and boys in science examinations in the pre National Curriculum period. There are many accounts providing biological explanations for sex differences, for example, Purvis (1987) described work by scientists in the 19th century attempting to prove that men were 'naturally' superior to women in their physical, mental, emotional and creative abilities. Any differences the scientists found in performance between males and females were assumed to be innate. Research presented by Birke (1986) into biological sex differences (chromosome differences, the ageing process and hormones) and by sociobiologists (Morris, 1969; Tiger and Fox, 1974; Wilson, 1975) in the 20th century supported the view that the process of human survival and the requirements of a healthy society are dependent on sex differences. Hutt (1972a) argued that many of the characteristic features of male and female behaviour have biological bases (males as stronger, more ambitious and aggressive, more objective and females as maturing more quickly physically and psychologically, with proficient verbal skills, more nurturant and more subjective). But she went on to argue that these biological bases are overlain with many socio-cultural influences operating from the moment of birth. Hutt (1972a) stated that these influences:

...operate on an already differentiated organism - an organism that already has a predisposition to sense and act in one way rather than another. Parents, society or culture operate to modulate or amplify the predispositions already extant; it is desirable that they should. It is here that biology and social reform come into conflict. (p.133)

Gipps and Murphy (1994) critiqued Hutt's research (1972a, 1972b) and argued that Hutt used evidence from selected items in intelligence tests to support her view that males and females think differently. These intelligence tests had been constructed so that overall there should be no sex differences and the tests were designed to reveal differences in patterns of intellectual ability. Hutt never made problematic the measures she was using, she simply interpreted the differences without paying heed to sociological factors or artefacts of the tests (for example language used in texts or

illustrations) she was using. In her small scale, individual research she was trying to prove an effect and she used her research instruments to show that any differences between males and females were caused by biological differences.

Major reviews in the US (as opposed to small scale individual research in the UK (Hutt, 1972)), like that of Maccoby and Jacklin (1974, 1975) provided evidence of the similarities in the abilities of boys and girls and challenged Hutt's position. Where differences were noted, they were very small between gender groups. Some of the differences, noted by Maccoby and Jacklin (1975) in their summary and analysis of research in the previous 10 years reported that some sex differences in ability were fairly well established, and at age about 11, girls were better than boys in terms of verbal ability; at about 12 or 13, boys' mathematical skills developed faster than girls in tests requiring judgement and manipulation of spatial relationships; and they reported that these skills were particularly important in the physical sciences. They also found that girls and boys were similar in their overall self-satisfaction and confidence. They reported some qualitative differences in the areas where girls and boys displayed their greatest self-confidence, with girls rating themselves higher in terms of social competence; boys rating themselves as stronger, more dominant and powerful; and some boys had greater confidence in their self-assessed performance on a variety of school tasks.

Later research (Fairweather, 1976; Maccoby and Jacklin, 1980) also established some differences in cognitive abilities between males and females based on differences in performance but the differences were very small. Hyde (1981) in her review also suggested that Maccoby and Jacklin's review (1975) considered well-established differences between the performances of boys and girls, but the reported differences were very small. Research (Fennema and Tarte, 1985) argued specifically that gender differences in spatial ability, if any, were minimal and hence the contribution of spatial ability skills to mathematics and physics performance had been over-stated.

Halpern (1992) reviewed and synthesised existing research literature about whether cognitive differences between the sexes existed, and if they did, whether they could be attributed to innate or to socio- cultural influences. *On the basis of this review Halpern (1992) argued that biological influences may be important at extremes of performance, but often sex was only one influential factor. In the preface to her book she noted from some of the research literature on sex differences in cognitive abilities, the overall view at the time, (the orthodoxy) was that although there were:*

...many inconsistent findings, contradictory theories and emotional claims that are unsupported by the research. Yet ... a clear and consistent message could be heard. There are real, and in some cases sizeable, sex differences with respect to some cognitive abilities. Socialisation practices are undoubtedly important, but there is also good evidence that biological sex differences play a role in establishing and maintaining cognitive sex differences... (Halpern, 1992, p.vii.)

Halpern (1992) focused her reanalysis and review on three cognitive abilities: verbal, quantitative and visual-spatial. She reported that sex differences in verbal, mathematical and spatial ability *were only found on selected ability tests (e.g. mental rotation, water level tests and some tests of verbal proficiency)* in childhood but that at adolescence clear differences emerged. Halpern (1992) also suggested on the basis of her review that spatial abilities could be 'trained' and that schools should incorporate spatial skills training into their curriculum (p.134). Findings such as these support the argument that social forces can effect cognitive performance.

Halpern found that verbal abilities, where girls had the advantage, were the least studied of the three areas of sex ability difference. Some research had suggested that verbal abilities were more subject to environmental influences, but there was no conclusive evidence. The research suggested that there was more likely to be a biological-environmental interaction affecting these abilities and that psychosocial pressure can exacerbate cognitive sex differences. Halpern's overall finding was that over time measured sex differences had decreased and she argued that:

Effect sizes with respect to sex differences in cognitive abilities have been decreasing provides the strongest case for the importance of psychosocial variables. (Halpern, 1992, p.143.)

Overall she challenged the research view reported in her preface and argued that, for people within the middle range of abilities, (the vast majority of the population), psychosocial explanations for *cognitive sex differences were more powerful than biological ones.*

Hyde, Fennema and Lamon (1990) in their review also found that the gender gap in measures of cognitive ability had closed in the last twenty years. Archer (1992) too provided evidence that there had been a considerable narrowing of the gender gap in cognitive abilities, such as verbal reasoning, mathematics and number reasoning, between 1960-1983 in the US. Earlier views held by Hutt (1972) and Wilson (1975) that sex differences in cognitive performance are biologically determined has not been supported by research.

Findings presented in this section suggest that the girls and science problem is not one attributable to girls themselves because they are innately less competent than boys. The more compelling view of the problem is that the environment (including out-of-school related activities) and opportunities to learn are major influences affecting the engagement of girls in the science learning processes and that biological or innate effects have a minor influence on these processes. In light of the research, and thus given the equal cognitive status of girls and boys, I move on to explore whether there are any gender differences in science performance and the possible factors influencing this performance.

1.1.3 Gender research – science performance

This section begins with a preview of general pupil science performance as researched by the previously mentioned international and UK-based surveys. International surveys are a major source of evidence of educational performance and have been carried out from the late 1960s until the 1990s. The first IEA study of 19 countries (First International Science Study (FISS) in 1970 (Comber and Keeves, 1973), showed that boys outperformed girls at all ages (age 10–11, 14-15 and 16-17) in tests concerning physics knowledge and chemistry knowledge (although there were less discrepancies in chemistry results compared with physics results) and in biology there were

smaller, less consistent, gender differences. These gender discrepancies increased through the ages. The study also showed that boys had more positive attitudes to science than girls. The second IEA study (SISS) (1983-1984) (documented in Postlethwaite and Wiley, 1992; IEA, 1988 and Keys and Foxman, 1989), showed similar results to the first study but overall gender differences in performance were smaller. These international surveys used a narrow range of assessments in contrast with the Assessment of Performance Unit, in terms of achievements considered and methods used. The APU² provided a much fuller picture of performance. The APU carried out five annual national science-monitoring surveys between 1980 and 1984. The surveys were conducted at each of three ages (11, 13 and 15) in three countries of the UK (England, Northern Ireland and Wales). The APU used broad measures in its provision of evidence on pupil performance that included process based, practical and written assessments, as well as paper and pencil content assessment (Johnson et al. 1983). The APU surveys had a remit to explore gender differences in performance. In the first APU survey conducted in 1980 (DES, 1982) of 15-year-olds, boys outperformed girls in four out of the ten types of test. These were reading off information, using apparatus or measuring instruments, data interpretation, and applying physics concepts. In the second year (1981), the APU survey (DES, 1984) results were similar to the first year. But across all three ages boys performed better in applying physics concepts, and the gender difference in performance increased with age (Johnson and Murphy, 1986). Johnson and Murphy found that in England, Wales and Northern Ireland:

...for the physics tests the performances of boys were consistently higher than those of girls and were, moreover, statistically significant in every country... at every age. (Johnson and Murphy, 1986, p.10.)

There was evidence that girls performed better on practical tests of 'making and interpreting observations' (Gipps and Murphy, 1994). Girls appeared to slightly outperform boys in the use of charts, graphs and tables at age 11, although this discrepancy in performance was in favour of boys by the age of 15.

² The gender differences reported as part of the APU surveys were based on samples from the whole populations of 11, 13 and 15 years olds with varied curriculum backgrounds in science. This population was different from the examination population at the time because before the introduction of the National Curriculum the examination population for science subjects was only a small proportion of the total year group.

Gipps and Murphy (1994) reflecting on evidence from the APU surveys conducted in the 1980s, and taking account of curriculum background showed that girls' and boys' performance at all three ages were very similar for the process skills surveyed; but the surveys revealed new differences in performance for girls as a group in certain content areas of physics, with the most extreme discrepancies on questions featuring electricity. International studies indicated that the gender gap in performance increased as children got older. The surveys also showed significant differences in gender performance in specific areas of science, particularly related to physics concepts. Some explanations and evidence to support them can be found in the APU measures of interest and experience. This showed that gender discrepancies were related to opportunities to learn, due to for example, timetable options and out-of-school science-related experiences. A key finding offered by Johnson and Murphy (1986) was that if curriculum background was taken into account at age 15 sex differences in performance between girls and boys had essentially disappeared, except in physics. Most of the research into gender differences in England in the 1970s and early 1980s was very concerned with the practice of options in schools, that is at age 14 pupils could opt out of the study of science. School structures, such as option choice allowed psycho-social factors to influence girls' engagement with science. If girls were already disinclined towards science, giving them the option not to study it was seen to further reinforce the channeling of girls away from science. Given that significant gender differences in science performance have been found I now examine the effects of the differential and gendered curriculum offered to pupils in the pre National Curriculum period.

1.1.4 The school structures – options

From the 1950s through to the 1980s educational attitudes and values affected institutions and they offered:

...different (science) courses of study for boys and girls on the grounds that their needs, interests and future lives would be different. (Manthorpe, 1989, p.126.)

Manthorpe suggested that such decisions about differentiating the curriculum was not merely a response to girls' negative attitudes towards some aspects of science, rather that this position had developed as a result of a century of social and educational policy focusing on the different needs and interests of girls and boys. Since:

...the nineteenth century schools and curricula have developed in a sex segregated way, firstly in relation to different conceptions of the male and female spheres and later, to a sexually segregated labour market. (Manthorpe, 1985, p.366.)

There was much debate over the decades through particularly the 1970s to the 1980s about how more girls could be encouraged to take up science as their optional subjects in school. At this time educators, industrialists and government members spoke of:

... 'an untapped pool', 'wasted women', 'a largely neglected source of recruitment', 'an important source of untapped ability' and so on. (Manthorpe, 1985, p.367.)

In the 1950s and 1960s very few girls studied any science other than biology, and then mainly human biology. Few boys studied science also, but when they did they studied a broader range of scientific subjects than girls. Manthorpe perceived that the solution to the problems were extremely complex. The idea that one could change girls' attitudes to adapt to their school science experience, without addressing issues other than educational ones, was not acceptable to her. She argued that many socio-cultural as well as educational changes must occur if girls were to participate equally with boys in school science. Manthorpe also suggested that there should be a new construction of science in schools where:

...the analytical fragmentation of modern science [moves towards] a holistic view in which social, ethical and moral considerations are unquestionably involved...[where there is] a respect for and equal valuations of different forms of knowledge, including the irrational and subjective. (Manthorpe, 1982, p.75.)

Before the National Curriculum was introduced in 1989, English, mathematics, physical education and games and religious education were compulsory for all pupils. Other subjects were offered to pupils in groups of subject options called blocks, with some subjects being available in more than one block (e.g. one block consisted of chemistry, physics, history, etc.). Other subjects, such as

'family and child', often occurred only once in the same block as certain academic subjects, for example science, thus limiting choices for the girls selecting this option.

Delamont and Galton (1986) observed some schools, in the late 1970s and mid 1980s that organized girls and boys into separate subjects, particularly for craft and office skills classes. Boys' classes in one school studied 'keyboard skills' and girls' classes studied typing. In another school not only were pupils segregated according to sex but they also studied different subjects, *with girls doing needlework and cookery and boys doing metalwork and woodwork.* Grafton et al. (1987) provided a detailed exploration of one co-educational school's option choices in 1980/81. They found that the structure of this particular curriculum was such that it would be less likely that boys and girls would choose non-traditional subjects, for example if pupils wished to study motor mechanics as well as 'family and child' the option structure would not have allowed it. Although *this was only one school it was fairly typical of option arrangements available in English schools at that time.*

The structures within schools were judged to limit girls' uptake and performance in school science. This position led to a period of change in terms of science policy and equity legislation. These changes are documented in the next two sections.

1.2 Response to the problem in England

1.2.1 Science policy

There was much consultation in the 1970s and 1980s between government departments and professional societies about the school science curriculum. A government consultative document 'Education in Schools' (Department of Education and Science (DES), 1977) suggested that all pupils should study a core curriculum composed of English, mathematics and science. This was reinforced by an independent report by Her Majesty's Inspectorate (HMI) (1979) which proposed that all pupils should participate in a balanced science course from 11-16 years to address concerns about the numbers of pupils studying no science or only one science subject at 14+. The DES

(1977) and HMI (1979) presented a similar view on concerns about school science provision. This resulted in the proposal that the science curriculum should aim to preserve a balance between the *contribution of science education to both personal development and scientific understanding*. Science was seen nationally as a priority subject, with the girls and science problem as an important concern. This concern focused on the small numbers of girls relative to boys entering for physical science examinations at 16+ and their relative achievements compared with boys. This led to even smaller numbers of girls opting to study science at higher levels post 16 and thus *restricted the numbers of young people particularly females appropriately qualified to take up scientific professions*.

There followed a range of surveys and reports that investigated ways to reconstruct school science. A DES consultative paper for Local Education Authorities (LEAs) 'A Framework for the School Curriculum' (DES 1980b) suggested that science should become a core subject and should take up between 10% and 20% of curriculum time. The DES (1980a) report suggested that there should be a major concern with attitudes and expectations of girls towards science and these were inextricably tied to the internal processes of schooling. This reinforced the earlier DES (1977) view on school science. In the same year HMI (1980) produced an independent report 'A View of the Curriculum', supporting the DES view and giving advice and recommendations to individual schools on how to present a broad and balanced science curriculum for all pupils. The DES consultation (1980) led to a further report (DES, 1981) which was the first document offering direct guidance to schools on the curriculum 5-16. It proposed that there should be breadth and balance in the science curriculum and expressed concerns about the large number of girls opting out of school science at 14+ and thus restricting their career choices. To counter this it suggested that all 11-16 year old pupils should have a curriculum of a broadly common character.

The Secondary Science Curriculum Review (SSCR) was established in 1981 to stimulate, through working groups of practising teachers, the development of science studies that would help to

provide a science education for all youngsters growing up in an increasingly scientific and technological society. It was concerned both with the science curriculum (contents, purposes, *teaching methods and resources*) and the role of science as a part of an individual and whole school general education policy. Planning and consultation with the SSCR during the early 1980s led to a Department of Education and Science (DES, 1982a) report, which reiterated that science should be a core subject for all. Consultation continued with the SSCR and culminated in a final report outlining Government policy for science. This policy stated that pupils should have a broad and *balanced science education and that this should take up 10% of curriculum time in Years 7 and 8, 15% in Year 9, and 20% in Years 10 and 11*. It was noted in a later report that science provision for lower attaining Year 10 and 11 pupils should not be:

... different in kind from that provided for average and more able pupils: it should, however, be differentiated in its treatment and should contain elements, which will enable the pupils to achieve success... (DES, 1985, p.22.)

In 1987 the DES produced a consultative document for schools and LEAs proposing that science should be a core subject for all, take up to a maximum 20% of curriculum time and that in the secondary sector it should lead to a GCSE award. An outcome of this consultation was that in July 1988 the Education Reform Act (ERA) established a National Curriculum that made science a compulsory core subject for all pupils aged 5-16 years old. It was hoped that the new science curriculum would remove some previous difficulties in terms of content and gendered options as it would include physics, chemistry and biology and would be compulsory for all pupils from 5-16 years old. In addition to science the National Curriculum for secondary schools also made four other subjects compulsory for all pupils: mathematics, English, technology and a modern foreign language.

The statutory orders in science described four attainment targets (ATs): AT 1 Scientific Investigation; AT 2 Life and Living Processes; AT 3 Materials and their Properties; AT 4 Physical Processes. Each attainment target was subdivided into strands of progression and statements of attainment, indicating how the main scientific ideas developed through the National Curriculum

levels. All science courses from 5-16 years, now incorporated the science investigation (Sc1) as a positive response to the policy debates in the 1980s. In order to work towards competence in Sc1 *pupils were expected to develop skills concerned with the process of science investigation*, sometimes called procedural understanding. The components of procedural understanding could be summarised in terms of three strands: ask questions, predict and hypothesise; observe, measure and manipulate variables; interpret results and evaluate scientific evidence.

A 50 per cent weighting for AT1 and 50 per cent in total for the other three attainment targets (AT 2-4) in primary and a 20:80 per cent weighting in secondary meant that there was a lot of time available using practical approaches, particularly in the primary sector, and giving value to procedural as well as content knowledge.

The ATs were planned in relation to Key Stages as follows:

Key Stage 1 (age 5 - 7) supports ATs 1 - 4 (all strands); levels 1 - 3;

Key Stage 2 (age 8 - 11) supports ATs 1 - 4 (all strands); levels 2 - 5;

Key Stage 3 (age 11 - 14) supports ATs 1 - 4 (all strands); levels 3 - 7.

National assessment was introduced to correspond to the National Curriculum with external tests in science (maths and English) at the end of Key Stages 1, 2 and 3. Alongside the development in the curriculum there were radical changes in the examinations at 16+. The new General Certificate for Secondary Education (GCSE), introduced in 1985 and implemented in 1988, involved a change from the two tier system of General Certificate in Education (GCE) Ordinary (O) level and Certificate for Secondary Education (CSE) examinations. In order to take a balanced science GCSE, pupils had to take a science course as either a 'single' award course (12.5% of curriculum time) or a 'double' award course (20% of curriculum time). Consequently the National Curriculum in science represented a move away from separate sciences towards balanced science at the double or single GCSE award level. Many independent and selective state schools retained an entry pattern

that incorporated the three separate sciences (biology, physics and chemistry) taught as separate subjects. However the majority of state maintained schools made the transition to balanced science courses for all pupils (Macfarlane, 1992).

The new examination included changes suggested in assessment research findings (DES, 1988b). The assessment research (included research into examination practices, significantly Roger Murphy, (1982); the Assessment Monitoring Strategy, (DES, 1982, 1984); Johnson and Murphy, (1986) and Gipps and Murphy, (1994)) resulted in educators considering the effects of different assessment strategies on different groups of pupils in schools. (For a detailed discussion see Murphy (1989) and Gipps and Murphy (1994).) This led to an outcome whereby the new examination papers used more everyday language, the questions were sometimes semi-structured and the use of multiple choice questions was avoided as previous research had shown that boys performed significantly better than girls on these types of questions (Gipps and Murphy, 1994). An assessed coursework component was introduced at this time. The Royal Society (1992) supported the transition to double award balanced science because it was suggested that this examination would meet the needs of all pupils including those who would eventually become the nation's leading scientists.

1.2.2 Equal opportunities policy

During the 1970s there was a growth in women's movements and civil rights movements particularly in Europe and the US. These highlighted issues associated with sexual inequality and compared them with the already identified equality issues associated with race and class. In the UK this increased awareness of inequalities eventually culminated in the Sex Discrimination (1975) and Race Relations (1976) Acts. This led to a broadening of the concept of equality of opportunity as gender, race and class became the major focus of the equality agenda.

The Sex Discrimination Act (SDA) made it illegal for schools and local education authorities to discriminate between girls and boys in the provision of any educational benefit or facility.

However, it did not require schools or local educational authorities to draw up policies in terms of equality of opportunity, and it became evident that boys and girls were still selecting subjects at school, *associated with traditionally stereotyped choices*. A DES document (1981) stated that in light of sex discrimination legislation the curriculum should change to ensure that equal opportunities were genuinely available to girls and boys. This document also advised that girls:

... should avoid closing career avenues by making inappropriate choices...
(Orr, 1985, p.9.)

The SDA contained several clauses designed to reduce sex segregation in terms of option choices and organisational arrangements. One way in which some schools began to implement these policies was by improving curriculum access policies so that all pupils would have equal choices. However DES Statistics of Education (1978, 1988) on subject entry, particularly in science subjects, did not indicate any rapid movement by girls or boys into subject areas which had been previously considered non-traditional (i.e. girls into physics and boys into biology), suggesting that equal opportunities policies were not being implemented or were not being effective. DES data (1978) indicated that in all schools in England very few girls were entered for science examinations at GCE and CSE level (6% physics, 8% chemistry, 7% science) compared with boys' entries (27% physics, 16% chemistry, 34% science). A reverse trend was observed for biology examination entries (28% girls and 16% boys). This data also indicated that the numbers of pupils studying science were very low, well below fifty per cent.

The Equal Opportunities Commission (EOC) was established in 1975 to monitor effects of inequalities and to provide guidance for individuals and institutions about how to address these inequalities. The EOC survey of the content and organisation of the school curriculum, in the late 1970s and early 1980s, revealed that in spite of the SDA there were still gender problems in schools:

- within a largely co-educational system different patterns of education and different educational experiences are identifiable for girls and boys;
- the outcome of the education system is unequal and is generally less favourable for girls regardless of their ability and aptitude. (EOC, 1985, p.1.)

Some UK research supported this position and in particular that many girls, and some boys, were still avoiding the sciences in Years 10 and 11 so that girls were still disadvantaged in terms of future choices (DES, 1980; Royal Society and Institute of Physics, 1982; Kelly, 1981; Johnson and Murphy, 1986). The annual reporting of CSE and GCE O-level statistics (covering the period 1970-1980) by the Department of Education and Science (DES 1985), revealed that smaller numbers of girls than boys were choosing science, and particularly the physical sciences, at 14+, also that girls generally exhibited lower levels of achievement in the physical sciences compared with boys. Furthermore, boys' subject entries decreased in the order physics, through chemistry to biology and the reverse for girls. The concern in the UK was matched by similar concerns in other countries, for example the US, Denmark and Norway (Kahle, 1985; Sørensen, 1985; Beyer and Reich, 1987 and Sjøberg and Imsen, 1991).

Concerns about the girls and science problem led to the establishment of interventions tailored to address some of the factors in the teaching and learning environment associated with these inequalities.

1.2.3 Interventions

A variety of interventions were introduced in the 1980s (in the UK and world-wide) as a consequence of policy commitment and legislation partly to create a climate for change and partly by legitimizing initiatives of educational pioneers (Whyte, Deem, Kant and Cruickshank, 1985). These interventions were established to address some of the inequalities in educational provision in schools and to explore the reasons for girls' lower performance in, and less positive attitudes to, science compared with boys. The interventions looked at major variables within school social structures that were having an effect on groups of girls and boys. It was suggested that attitude differences between these two gender groups were emerging because of the influence of psycho-social effects. The interventions were not trying to measure them, but were exploring the causes

and how the interventions could go some way to ameliorate the differences. In this section I explore some key large scale, policy funded interventions that addressed issues such as curricular reform, *pupil options with respect to gender inequality and the position of girls in school science*.

The GIST project (Smail, Whyte and Kelly, 1982) was a major piece of action research, funded by the EOC/SSRC (Equal Opportunities Commission and Social Science Research Council) undertaken from 1980 to 1983. GIST was an example of a form of affirmative action (focused on girls and science) *moving beyond equality of opportunity towards challenging pedagogical practices and existing school structures*. GIST involved a cohort of 2000 children in 10 co-educational comprehensive schools in the Greater Manchester area. The pupils were in Year 7 (aged 11 or 12 years) at the beginning of the project and in Year 9 (aged 13-14 years) at the end.

Beliefs about the existence of the 'hidden curriculum', which differentiated on the basis of sex and *the effect of teacher attitudes on pupil learning in science*, affected how the GIST team set up their intervention project. The 'hidden curriculum' is concerned with both the implicit and the formal aspects of the curriculum. It involves the many assumptions and procedures acting to influence girls' motivation in school and their subject choices. The team organised workshops with the teachers rather than the pupils to challenge the teachers' perceptions and attitudes in order to deal with *gender inequalities in the school*. Implicit in this is that teacher attitudes towards pupils have an influence on pupils' developing attitudes. Whyte (1983) stressed the need for teachers to reflect on their teaching styles and attitudes in order to support change in classrooms. Teachers were provided with information about sex differences in achievement and attitudes to science and other findings from research in science education (Girls and Science and Technology (GASAT), 1981, 1983; Kelly, 1981; Whyte, 1983). The team also arranged for women working in science to visit pupils in school to provide positive role models, the researchers worked with teachers in supporting the development of more 'girl friendly' curriculum materials and changing patterns of classroom interaction to encourage greater girls' participation.

The GIST research team hoped to:

...reduce sex-stereotyping on the part of the pupils and teachers, and to promote 'gender-fair' interaction in classrooms, so that girls would feel more encouraged to study science subjects. (Weiner and Arnot, 1987, p.364.)

The GIST team did attempt to establish for the cohort what differences in performance existed and found little difference in the scientific content knowledge of boys and girls, aged 13 and 14, but did note differences in the relative performance of boys and girls on tests of spatial ability and mechanical reasoning - the boys came out better. However, after girls and boys in one study school were given spatial ability workshop sessions (where girls could catch up on the experiences they lacked because of gender stereotyping in the home) they all showed an improvement in their performance in spatial ability tasks (Whyte, 1986). These sessions indicated that with appropriate teaching, girls could perform as well as boys in spatial ability work, which further supports the notion that the differing abilities of girls and boys in science performance are not due to innate differences. This minor part of the project was addressing the effects of out-of-school socialisation practises on pupil abilities - when given appropriate 'catch up' workshop sessions girls performed equally well as boys on certain tasks.

One positive result from the research was the success of the dissemination of project ideas and strategies to make science more 'girl friendly' and the impact this had on the project schools. Other positive results were that girls' attitudes towards science became more positive in the action schools but there was little impact on behaviour in terms of subject choice at 14+. Pupils became less stereotyped in their views on science, saw science as less masculine and there was less decline in interest in school science in the action schools than in the control schools. The GIST team reported that the extent of the intervention in challenging some school norms was very dependent on the school ethos³ and that change was more likely to occur if the school ethos supported the intervention. The researchers found that many staff did not see girls' under representation in science as a problem and were unwilling to re-examine their own values. There was some

³ School ethos is a combined effect of teacher and pupil attitude, school structures, the teaching and learning environment, teaching styles, school aims and objectives, etc.

evidence (from field notes and an evaluation report) of teacher attitude and behaviour change, for example, when developing new curriculum materials teachers intentionally avoided sexist language⁴ and actively thought about ways to increase girls' participation in science (Whyte, 1983).

I feel that this project had little effect as its main focus was on challenging teachers' attitudes rather than exploring pupil experiences within the classroom. The research findings indicated that teacher attitudes would have an effect on the development of pupil attitudes, but did not consider teacher's influence more broadly. Observations of pupils in the classroom can be used as an indicator of school ethos, but the GIST researchers focused on teachers not pupils in the classroom. The intervention team did not investigate the effects of school ethos in the different action schools, although they found that the effect of school ethos was important in terms of the acceptance of the interventions aims.

A further major initiative, though this time one funded by Government was established to generate curricular changes by offering vocational courses to middle to low attainers. The 'Technical and Vocational Initiative' (TVEI), was established to broaden employment opportunities (particularly for girls and women) by bridging the gap between school and work and producing more skilled youngsters who were better prepared for the workforce. This was launched in 1983 (after the GIST project) for pupils between 14-18 years old. Central to this intervention was an equal opportunities agenda. The funding agency expected Local Education Authorities (LEAs) to meet equal opportunities requirements, and stated that equal opportunities should be available to young people of both sexes, that they should normally be educated together on courses and that care should be taken to avoid sex stereotyping (MSC, 1984). This initiative was very localised and dependent on voluntary participation of LEAs, thus national effects could not be monitored. The Women's National Commission (WNC) and the Equal Opportunities Commission (EOC) were concerned to see that equal opportunities policies were put into practice through the TVEI project. Unfortunately the structure of most of the pilot programmes, (despite roughly equal numbers of

⁴ Spender (1980) argues that sexism in the English language is well substantiated and Berger and Kachuk (1977) argue that the English language is sexist as it relegates women to an inferior position and secondary place in society with respect to men.

girls and boys participating) in the first 14 LEAs was blatantly sex-stereotyped (Millman, 1985). Many TVEI projects had deliberately set male and female options against each other and girls remained concentrated within Technical and Vocational Education in the traditionally female subject areas (for example nursery nursing, social care and health studies). The WNC and EOC requested that during the second round, LEAs should be given more guidance to support their commitment specifically to equal opportunities. Dale, et al. (1990) reported it was difficult to evaluate the success of the promotion or counteraction of sex-stereotyping for the second round initiatives, because it depended heavily on the individual LEAs and their previous experience of equal opportunities involvement. Another difficulty occurred because the projects' aims, objectives, methods and strategies were unclear to many participants at all levels of implementation. The project failed in its attempt to address sex-stereotyping in subject uptake. I include this intervention here to further illustrate that sex-stereotyping, in terms of subject uptake, was seen as a key factor affecting pupils' future employment opportunities and this reflected what was happening in school science education. It is important to understand pupil positions with respect to the reasons they are making particular choices.

The Women into Science and Engineering (WISE) project was a parallel national initiative to TVEI, established to encourage more girls and young women into careers in science and technology. Its major focus was on post-school employment activities of girls, particularly in engineering. The Engineering Council, in collaboration with the EOC, sponsored 1984 as WISE Year. WISE developed specific initiatives where female scientists played a major part as role models, because research had suggested that the influence of female role models as scientists might positively influence girls to embark on careers in science. A great many educational institutions and employing industries attempted some form of activity to encourage more girls and women into science and engineering professions. Various WISE initiatives continued for several years and the most commonly used were the six WISE buses that had been converted into mobile technology classrooms where 13-14 year old girls could experience microelectronics and other technologies, and explore associated career opportunities. Employment data indicated only minor changes in

terms of uptake of non-traditional occupations by girls and young women. This project's success was limited because it simply attempted to influence girls' participation in science using female role models and the WISE buses for girls to participate in 'tinkering' activities. (The GIST project mentioned earlier also partly focused on tinkering activities and provided girls with 'catch up' sessions in areas where girls had less related out-of-school experiences than boys).

The interventions discussed looked at a range of factors influencing girls' participation in school science but none investigated pupils' attitudes and the way in which gender socialization and classroom and school experiences influence the development of these attitudes over time. The GIST intervention was local and therefore limited in what it could achieve and funding was not available to research the long term effects of the project. The WISE and TVEI projects were nationally funded but focused on careers and encouraging girls into less sex-stereotyped employment. Simultaneously there was much debate leading to major educational policy changes in England. In the next section I consider entry and performance levels at 16+ pre and post interventions and policy changes in curriculum and assessment, to explore whether these changes have impacted on entry and performance in school science examinations from a gender perspective.

1.3 Effects of the responses on examination performance in science

1.3.1 Gender differences in entry and examination performance in science at 16+, pre and post the introduction of the National Curriculum (1978, 1988 and 1993)

GCE and CSE examination achievements are one commonly used source of data about girls' and boys' performance in school science. (Pupils were selected for entry into either the more academic GCE or the CSE. Grade 1 achievement at CSE was awarded equivalent status to a pass at GCE).

In 1978, a decade before the introduction of the National Curriculum, those pupils opting for science subjects at 14+ did so on a voluntary basis and therefore it was expected that pupils

selecting science subjects would be keenly interested and would achieve well in these subjects.

The entry and performance data for this year are presented in Table 1.1 and 1.2.

Table 1.1 Number of science entries⁵ for GCE and CSE in all schools in England in 1978.

Subject	Boys	% of total year cohort	Girls	% of total year cohort
Physics	167,450	23.1	39,760	5.5
Chemistry	101,060	13.9	50,870	7.0
Biology	103,160	14.2	177,250	24.5
General Science	212,640	29.4	45,870	6.3

Source DES Statistics of Education, School Leavers CSE and GCE, 1978.

The data in table 1.1 shows many more boys than girls entered for General Certificate in Education (GCE) and Certificate in Secondary Education (CSE) physics and general science, twice as many boys than girls entered for chemistry, and almost twice as many girls than boys entered for biology examinations. DES data for all schools in England in 1978 was explored and the number of pupils achieving pass grades in their GCE examination or CSE grade 1 was presented as this was a traditional criteria for monitoring school systems in the UK at that time.

Table 1.2 School leavers⁶ during the academic year 1977-78 'O' level GCE and CSE attempts and graded results⁷ by subject groups.

Subject	Boys' entry	Boys pass 'O' level and grade 1 at CSE	% Pass boys	Girls' entry	Girls pass 'O' level and grade 1 at CSE	% Pass girls	Difference in % pass rate
Physics	167,450	67,060	40.0	39,760	19,600	49.3	+9.3
Chemistry	101,060	47,700	47.2	50,870	22,280	43.7	-3.5
Biology	103,160	44,510	43.2	177,250	63,960	36.1	-8.1
General Science	212,640	67,840	31.9	45,870	9,390	20.5	-11.4

Table 8 p.23 DES Statistics of Education. School Leavers GCSE and GCE in England. 1977-1978.

⁵ Total year population of pupils, aged 15 on August 31st 1977. (Boys 372,129, girls 352,190; totals 724,292).

⁶ Total year population as numbers of pupils, aged 15 on August 31st 1977. (Boys 372,120, girls 352,190; total 724,292).

⁷ Excluding 'O' level passes on 'A' level papers.

The data in table 1.2 illustrates the relative success of boys and girls who had opted to study science subjects. Girls achieved higher percentage pass rates than boys in physics and boys achieved higher percentage pass rates in chemistry, biology and science. The few girls selecting physics outperformed the boys by a large margin, but overall this data illustrates clearly that in 1978 boys were achieving better in the majority of science subjects than girls.

From this time (1978 and continuing to the early 1980s), the influence of policy and interventions had led some teachers and advisory staff to develop strategies to counter some gender inequalities (Orr, 1985). For example, pupils were encouraged to opt for non-traditional subjects, like physics for girls, and school texts were revised to make them more gender inclusive and included fewer stereotyped examples, such as females carrying out tasks in the kitchen and males working on cars. But DES statistics (1982 - 1985) on subject entry, particularly in science, did not indicate any rapid movement by girls or boys into subject areas that had been previously considered non-traditional.

Table 1.3 Number of science entries⁸ for GCE and CSE in all schools in England in 1988.

Subject	Boys	% of total year cohort	Girls	% of total year cohort
Physics	158,530	26.8	63,510	10.7
Chemistry	105,300	17.8	81,340	13.7
Biology	88,870	15.0	158,080	26.7
General Science	180,880	30.6	73,280	12.4

Source: DES Statistics of Education, School Leavers CSE and GCE, 1988.

The data in table 1.3 shows that in 1988 there were many more boys than girls entered for GCE and CSE physics and general science, marginally more boys than girls entered for chemistry and almost twice as many girls as boys entered for biology examinations. When comparing data in Table 1.1 and 1.3 (from 1978 to 1988) there were increases in the percentage of boys and girls taking

⁸ Total year population as numbers of pupils, aged 15 on August 31st 1987, attempting or not attempting examinations: (boys = 298,390, girls = 293,270; total = 591,660).

physics, chemistry and general science; for boys this percentage increase was much smaller than for girls where the numbers taking these subjects almost doubled. These effects could possibly be related to the influence of interventions, but no research was carried out to explore this. Percentage biology entries from 1978 to 1988 period remained approximately the same for girls and boys. Performance results are given in Table 1.4.

Table 1.4 School leavers⁹ during the academic year 1987-88 'O' level GCE and CSE attempts and graded results¹⁰ by subject groups.

Subject	Boys' entry	Boys pass 'O' level and grade 1 at CSE	% pass boys	Girls' entry	Girls pass 'O' level and grade 1 at CSE	% pass girls	Difference in % pass rate
Physics	158,530	73,330	46.2	63,510	31,240	49.2	+3.0
Chemistry	105,300	55,370	52.6	81,340	38,310	47.1	-5.5
Biology	88,870	43,130	48.5	158,080	63,020	39.9	-8.6
General Science	180,880	64,210	35.5	73,820	18,920	25.6	-9.9

Source Table C12 (C8) p.16 DES Statistics of Education. School Leavers GCSE and GCE in England. 1987-1988.

Table 1.4 illustrates that the percentage of girls passing physics is higher than the percentage of boys passing and the percentage pass rate for boys is higher than girls in chemistry, biology and science. A comparison between the data in tables 1.2 and 1.4 shows that over the 1978 - 1988 decade the percentage pass rates for girls remained the same in physics (but improved for boys in physics) even though there was a large increase in girls' entry in 1988. The gender difference in performance over the decade showed that girls performed better than boys in physics but the gap between their performances in favour of girls was reducing.

The pass rate for girls improved in chemistry and biology but the gender gap in performance was increasing to advantage boys. In general science girls' pass rate increased and the gender gap between their performance and boys' decreased. In this period pupils opted for their science

⁹ Total entry any subject (boys = 298,390, girls = 293,270, total = 591,660).

¹⁰ Excluding 'O' level passes on 'A' level papers.

subjects and might therefore be expected to have a positive motivation and interest in these subjects.

Data for 1993 is presented here to illustrate how the introduction of the National Curriculum and other associated changes in school science impacted on examination entry and performance. The entry and achievement patterns of this year group (1993) of pupils cannot be directly compared with previous year groups reported for 1978 and 1988 because the cohorts are different and GCSE *balanced science at double award level had become the main science examination*. Even so, a consideration of girls' and boys' entries and achievements in school science subjects helps to indicate the extent to which policy shifts succeeded in addressing the girls and science problem and provided evidence about girls' potential to 'do' science.

Table 1.5 Entries¹¹ for GCSE in all schools in England in 1993.

	Boys	% of total year cohort	Girls	% of total year cohort
Physics	29,867	5.8	14,381	2.8
Chemistry	26,966	5.3	17,917	3.5
Biology	24,511	4.8	24,046	4.7
Double Award Science	158,137	30.9	156,129	30.5
Single Award Science	39,597	7.7	43,255	8.4

Source DFE Statistics of Education, School Leavers GCSE.1993.

The effects of the introduction of the National Curriculum with its compulsory science (double award, single award or separate sciences) for all pupils are illustrated in table 1.5. The vast majority of Year 11 pupils in 1993 (76% of all boys and 79% of all girls) took science examinations, (compared with 61% of boys and 13% of girls taking general science in 1987). This represented a massive increase in entry to science (Double and Single Award) examinations. Consequently the number of pupils taking separate science subjects decreased. The problem of the gender difference in science uptake that was evident before the introduction of the National Curriculum was addressed by these policy changes.

¹¹ Total year population as numbers of pupils, aged 15 on August 31st 1992 (boys = 260,920, girls = 251,210; total =512,130).

GCSE achievements for pupils starting their GCSE courses two years after the introduction of the National Curriculum in all schools in England are shown in Table 1.6.

Table 1.6 GCSE entries and achievements of 15-year-old pupils¹² in all schools by subject group and grade, by end of 1992 – 93

Subject	Boys' entries	Boys A-C grades	% Boys A-C grades	Girls' entries	Girls A-C grades	% Girls A-C grades	Difference in % A-C grades
Physics	29,867	21,998	73.7	14,381	10,905	75.8	+2.1
Chemistry	26,966	20,044	74.3	17,917	12,944	72.2	-2.1
Biology	24,511	18,523	75.5	24,046	16,452	68.4	-7.1
Single Award Science	39,597	5,722	14.5	43,255	8,872	20.5	+6.0
Double Award Science	158,137	71,306	45.1	156,129	71,078	45.5	+0.4

Source Table 3 p.9-10 DFE Statistics of Education in Public Examinations GCSE and GCE 1993. HMSO

Achievement data in table 1.6 for the 1993 cohort showed that girls outperformed boys in science at the Single Award level and performed equally well in Double Award science. The small numbers of pupils entered for separate science examinations showed a gender skew in performance with boys performing better than girls in biology and chemistry and girls performing better than boys in physics, similar to previous patterns, but with much improved pass rates. This science examination performance data indicates that when girls were made to study science as a part of the National Curriculum they performed equally as well, if not better than, boys.

The entry numbers for all pupils at science GCSE examination level had risen in the five years after the introduction of the National Curriculum. Since 1988 girls attending all schools in England (i.e. maintained and independent) made up more than 50% of the GCSE science examination entry (DES, DFE, DfEE, 1988-1993). In 1993 more than three quarters of all 15-year-old school pupils were entered for balanced science GCSE examinations at Double or Single Award level. More than half (61.3%) of the whole school population of 15-year-old pupils took the Double Award

¹² Those pupils aged 15 at 31 August 1992.

Science examination, with a fairly even gender distribution (158,137 boys and 156,129 girls, DfEE 1993.) Sixteen per cent of the whole school population of 15-year-old pupils attempted Single Award GCSE science. *The course leading to this award has anecdotally a lower academic status than Double Award or separate sciences.* More girls than boys (43,255 girls and 39,597 boys in 1993) were either self or teacher selected to study this minimum science course. In 1993 a very small proportion of the school population of 15-year-old pupils were entered for the separate science examinations. Of those pupils twice as many boys than girls were entered for GCSE physics and also more boys than girls were entered for chemistry and biology as separate sciences. DfEE data was not available for numbers of pupils not taking science examinations but very small numbers of examinations were ungraded (less than 1% of all entries to separate science examinations, 1.5% boys, and 1.4% girls entered for Double Award examinations and 6% boys and 5.2% girls entered for Single Award science exams).

From 1988 to 1993 girls and boys improved their GCSE pass rates at grades A to C in science. In 1988 boys outperformed girls in science by a large margin, but by 1993, the great majority of pupils entered balanced science examinations at the Double Award level and girls and boys performed equally well. This demonstrates a very positive gain for girls in science. In 1993 in science Single Award examinations girls outperformed the boys. The relatively low pass rate (see Table 1.6) for all pupils entered for single science suggested that this exam may have been used for the less academic and that the girls entered were more able than the boys; this could in some way account for the much better pass rate for girls at this level. Evidence from Stobart et al. (1992) indicates that more boys than girls are not entered for examination and that suggests that the sub groups of boys and girls do differ. A comparison of results for pupils taking physics, chemistry and biology in 1988 and 1993 is difficult because of the low numbers entering after 1988. But in terms of performance, boys outperformed girls in chemistry and biology in 1988 and 1993 and girls outperformed boys in physics in 1988 and 1993. The higher percentage pass rates in separate science subjects in 1993 suggest that the pupils taking these examinations were from a very able selected group.

1.3.2 Performance at 18+, pre and post National Curriculum – attitudes and achievement.

Many educators predicted that pupils who had earlier avoided science subjects would start opting for science at A and AS level as a result of compulsory science study at pre 16. But these predictions did not assess the influence of pupils' attitudes on choice of subject for study at 16+.

A number of research studies have explored the impact of pupils' attitudes towards school science and the relationship of these attitudes to achievement. Researchers do not agree on the magnitude of correlation between achievement and attitudes to science, as there is no common agreement on what attitudes are. Some research suggests that the importance of positive attitudes to science in school is well established (Harlen, 1992; Raper and Stringer, 1987). Comber and Keeves (1973), Cannon and Simpson (1985) and Oliver and Simpson (1988) suggested that there was a significant positive correlation between attitude and achievement, although Comber and Keeves (op cit.) argued that attitude was only one of the factors contributing to positive achievement. In the same study, Keeves suggested that achievement in science is substantially affected by attitude towards science and that there is a two-way relationship.

Kelly (1978) found that girls at secondary school had less favourable attitudes towards science than boys and there was a connection between attitudes and achievement: good attitudes were associated with high achievement. Moreover she reported girls' and boys' attitudes towards science varied from country to country which suggested that attitudes could be susceptible to improvement. However, she argued that boys' achievement was more highly correlated with attitude than was girls' and boys achieved better in science than did girls with equally favourable attitudes. Steinkamp and Maehr (1983) quoted studies that supported the position that the affective environment had an influence on achievement and vice versa and that attitudes and achievement reinforced one another. Fraser (1982) reported from Willson's (1980) meta analysis of 14 studies

in the United States, Great Britain, Israel and Australia, that the relationship between attitudes and achievement was quite weak and he stated that:

...the strong link between attitude and achievement commonly assumed to exist by science teachers has no empirical foundation. (Fraser, 1982, p.558.)

Keys (1987) found little correlation between liking for school science and achievement in both the primary and secondary sectors of education. She also found low but statistically significant differences between achievement and attitude towards working in school science and weak association between measures of educational aspiration and science achievement. Levin et al. (1991) related girls' underachievement in school science to their lack of confidence and interest, and low aspiration.

Rennie and Punch (1991) reported that pupils' attitudes towards school science affected both their motivation and achievement in science. They proposed a model of science-related affect (this model had its theoretical base in Bloom's (1976) theory of school learning). The model conceptualises science-related affect as a global variable with four causally related components. The model hypothesises that pupils' enjoyment and interest in school science are dependent on their perceptions (based on judgements of teachers and peers) of their past performance in science and their expected future performance relative to the rest of the class. They carried out their research with 350 middle class Grade 8 (age 13 years) pupils in Perth, Western Australia. They found that pupils' perception of previous performance was the most important component variable associated with achievement. They found that pupil interest and liking for various aspects of science had little effect on achievement and argued that this was the reason why much research on pupil attitudes has reported low correlation between attitudes and achievement.

Munby's (1980) and Schibeci's (1984) reviews challenged some of the achievement/attitude research assertions and suggested that studies had shown that there was a weak link between attitude and achievement because there was an ambiguity of construct definition and that the instruments used in many attitude studies were unreliable. They suggested that it was the

reliability of the construct definition rather than innate qualities of attitude that were affecting the research findings. Rennie and Punch (1991) also stated that incomplete descriptions of *achievement and attitude measures may have led to the low association between these variables* mentioned above. They also argued that some of the contradictions associated with research into attitudes towards school science could be as a result of a lack of theoretical framework to direct the investigations. Keys and Fernandes (1993) suggested that the strength of any association between attitude and achievement would be dependent on whichever attitude dimension was under consideration. *The dimensions they discussed were liking school, attitudes towards schoolwork, educational aspirations and self-esteem.*

The data on attitudes and achievement does not support an assumption that girls' success in science necessarily reflects a liking for, and positive attitude towards it. To explore this I consider next performance post 16 where options are relevant.

Entry and performance in vocational education

Since the TVEI project more technical and vocational courses were provided as options to school and FE college pupils. There was little systematically collected information on course choice in vocational qualifications from schools available in 1993. Where the information was available *choices for vocational courses tended to be sex stereotyped with boys and girls choosing different* courses leading to different occupations. Business and Technology Education Council (BTEC) course choices (Bailey 1992) illustrated a gender breakdown along traditional lines, with more boys in engineering, construction and computing programmes, and more girls in nursery nursing, social care, health studies. Boys were more likely to gain qualifications at higher levels than girls. But *there was a large decline in the numbers of registrations from 1988 to 1992 for Engineering BTEC* National Diplomas and Certificates (BTEC, 1988,1992).

Entry and performance at A level

Despite the increased success of girls at GCSE in science examinations following the introduction of the National Curriculum with its compulsory science component, there has been little change in the pattern of uptake of sciences at A level. Data for the 1988 A level cohort of pupils was selected as this was the year before the introduction of the National Curriculum. The 1993 A level cohort data was selected as it consisted of the first group of pupils completing compulsory science education from their Year 10. Table 1.7 compares entry patterns.

Table 1.7 Actual number of entries¹³ and percentage of year cohort (17 year old pupils only) at Advanced level GCE science in all schools and FE colleges in England in 1988 and 1993.

	1988				1993			
	Boys		Girls		Boys		Girls	
Subject	Actual entry	% of total A level cohort	Actual entry	% of total A level cohort	Actual entry	% of total A level cohort	Actual entry	% of total A level cohort
Physics	25,890	19.4	7,550	5.7	21,913	12.7	6,079	3.5
Chemistry	19,920	14.9	12,250	9.2	17,122	9.9	11,927	6.9
Biology	11,560	8.7	15,850	11.9	12,261	7.1	19,515	11.3

Source DfEE Statistics for Education, all schools and FE colleges in England, 1988/1993. Pupils aged 17 years on 31st August 1987/1992.

Table 1.7 data indicate that at A level in both 1988 and 1993 more boys than girls were entered for the physical sciences with the gender difference being greatest in physics and more girls than boys were entered for biology. The data also shows a decrease in percentage A level science entry for both girls and boys from 1988 to 1993. Smithers and Robinson (1994) argued that the introduction of Double Award science had three objectives: to improve scientific literacy, to correct gender imbalances and to improve science uptake at A level. They suggested that these first two objectives had been met but that the third had not yet. The data in table 1.7 shows that the introduction of balanced science GCSE courses was not yet having a positive effect on the uptake of sciences in the post compulsory period of schooling nor was it correcting gender imbalances. Girls were still not opting for physical sciences at A level in large numbers despite their increased success at GCSE. At A level boys dominated all sciences, except biological sciences. It was

¹³ Total A level population: 1988: 133,610; 1993: 172,850.

therefore possible that making science compulsory did not change attitudes towards school science as some had anticipated.

Some other explanations for the low level of uptake in physics at A level were reported by Smithers and Robinson (1988), Fitzgibbon and Vincent (1994) and Elwood and Comber (1996). Smithers and Robinson (1988) suggested that there was a move by schools and FE colleges towards offering a wider range of subjects at A level, for example, sociology, sports science, psychology, media studies and this may have affected uptake in science subjects at A level. The decrease in entry in science subjects could also be explained by a perception that these subjects were more difficult than other subjects at A level. Research carried out by Fitzgibbon and Vincent, (1994) found that:

...in 1993, physics was the most difficult A level followed by chemistry, mathematics and biology. (Fitzgibbon and Vincent, 1994, p.10).

A comparison of performance indicates again that girls' ability to achieve in science is not the source of the problem. The performance of males and females for 1988 and 1993 is presented in tables 1.8 and 1.9.

Table 1.8 The percentage entry and achievement¹⁴ in science subjects at A level in all schools and FE colleges in England by gender, in 1988.

Subject	% Entries		% Achievement at grade A - E		Difference in achievement
	Girls	Boys	Girls	Boys	
Physics	23	77	78.6	79.1	-0.5
Chemistry	38	62	78.8	81.3	-2.5
Biology	58	42	77.8	78.3	-0.5

Source: DES Statistics for Education, all schools and FE colleges in England, 1988. Pupils aged 17 years on 31st August 1987.

¹⁴ Total A level population: 133610 (69340 boys and 64270 girls).

Table 1.9 The percentage entry and achievement¹⁵ in science subjects at A level in all schools and FE colleges in England by gender, in 1993

Subject	% Entries		% Achievement A - E		Difference in achievement
	Girls	Boys	Girls	Boys	
Physics	22	78	82.5	81.8	+0.7
Chemistry	41	59	81.9	81.6	+0.3
Biology	61	39	79.4	79.6	-0.2

Source: DfEE Statistics for Education, all schools and FE colleges in England, 1993. Pupils aged 17 years on 31st August 1992.

Table 1.8 indicates a gender difference in performance at A level in 1988 with boys marginally outperforming girls in physics, chemistry and biology. The data in table 1.9 indicates that in 1993 girls outperformed boys in physics and chemistry and boys outperformed girls in biology. The differences in performance are very small but these data do suggest that the gender parity in achievement at Double Award science GCSE level has continued at A level, though this fails to take account of the very significant difference in the entry populations.

The data in this section indicate that since the introduction of the National Curriculum, balanced science courses and associated national assessment, gender differences in science performance and entry at GCSE level disappeared in Double Award science, indicating that when given the opportunity girls perform equally well as boys and therefore challenging the innate ability difference argument. But at A level, entry patterns still showed many more boys than girls choosing to study physics and many more girls than boys choosing to study biology, this indicates that there are still issues of concern associated with gendered uptake in the post compulsory period of schooling and that these issues may be related to pupils' attitudes towards school science subjects.

¹⁵ Total A level population: 172,850.

1.4 Discussion

By the 1980s it was generally agreed that girls' access to, and performance in, science was a problem. National and international surveys were used to explore gender differences in performance and to look for explanations for these differences in terms of attitude. Girls were found to have less experience of science related activities out of school and less positive attitudes towards their school science experiences than boys and in APU survey tests they performed less well than boys, particularly in physics. Gender research carried out at this time focused on the controversial explanations for these differences in performance and the research presented in section 1.1.2 provides strong support for the argument that differences in measured performance are more likely to be attributable to psycho-social forces than innate ability differences between the sexes. Gender researchers were concerned that the girls and science problem in terms of attitude and performance was very complex and required a multivariable approach to further understand it. Early research did, however, point to the need to reconsider school structures, in particular option choices. Examination entry data in 1978 indicates clear gender differences in science uptake and performance: four times as many boys as girls were entered for physics and General Science examinations, twice as many boys as girls were entered for chemistry examinations and twice as many girls as boys were entered for biology examinations. In terms of performance in 1978 girls outperformed boys in physics and boys outperformed girls in chemistry, biology and General Science. The positive relative performance of girls in physics examinations contrasts with APU findings, but the APU surveys were carried out with whole populations of pupils rather than the selected pupils opting to study physics for examinations. In 1988 the entry patterns were similar but there were improved entry rates for boys (and more so for girls) in physics, chemistry and general science. The performance patterns had also changed with improved pass rates for girls and boys in chemistry, biology and general science, in physics boys' pass rates had improved and girls' stayed the same. In separate science boys remained ahead of girls in their relative performance in chemistry, biology and in general science.

The response to the problem in England began with major science policy changes culminating with the introduction of the National Curriculum and associated assessment changes. This meant that all *pupils had to study science at 14+*. In terms of examination entry in 1993 twice as many boys as girls entered physics, one-third more boys as girls entered chemistry, roughly equal numbers of boys and girls entered biology and Double Award science and more girls than boys entered Single Award science. By 1993 boys continued to outperform girls in biology and chemistry and girls outperformed boys in physics, and Double and Single Award science. A comparison of these results revealed that *when given the opportunity girls were equally well able to achieve in science across subjects, except in biology and chemistry*. At A level however it was clear that many girls were still not choosing to pursue physical science subjects post 16, as in 1993 only 6079 (7550 in 1988) girls compared with 21913 (25890 in 1988) boys entered for physics, 11927 (12250 in 1988) girls and 17112 (19920 in 1988) boys entered for chemistry

At the beginning of my research although there was much interest and national and international research into gender differences (GASAT proceedings, 1981-1993) there was still no clear indication of the key source of the problems. Differences in attitudes to science had been established and reproduced in several national and international surveys. My personal experience supported these findings. I therefore wanted to explore the nature of attitude measures and consider the research that illuminated the process by which gender differences in interests are established.

2.1 Introduction

Gender differences in views towards school must also be considered in relation to factors such as social class and ethnicity (Arnot et al. 1998; Raphael Reed, 1998; Bleach, 1998). Riddell (1998) and Turner et al. (1995) claimed that although gender was a key influential factor on educational performance:

...[social] class and the associated level of education of parents (for both boys and girls) continue to be the most reliable predictors of a child's success in school examinations. (Epstein et al. 1998, p.11.)

Some effects of social class on performance were noted by the National Commission on Education (1993), which stated:

Children from social classes 1 and 11 do better, on average, in examinations at 16...and are more likely to go to university than those in social classes 111 to V. (p.8.)

Arnot et al. (1998) reported on the effects of class and race on educational performance. She stated that overall white girls from professional and intermediate classes outperform white boys, but African-Caribbean and Asian boys were outperforming their female counterparts from these classes. *For pupils of all races, from working class backgrounds, out-performance of girls over boys is consistent.* Kreinberg and Lewis (1996) presented findings from research programmes in Australia and the US. They argued that gender issues do not exist in isolation and that issues associated with ethnicity and class interplay and this affects pupil learning. They argued that although there has been an increase in the number of white, middle class females over the past decade enrolling on science and maths courses, similar changes have not occurred for ethnic minority and low-income pupils (in Australia and the US). In the UK Wright (1986) addressed issues associated with exclusion of ethnic minority pupils from school. Osler (1997a and b) presented data on exclusions in 1995-6 and raised issues associated both with gender and race, citing that African Caribbean boys are more likely to be excluded from schools than other pupils. *A further example of ethnicity effects is provided by Gillborn and Gipps (1996):*

Black pupils experience school in ways that were significantly more conflictual and less positive than their peers regardless of ability and gender: the patterns were true for black pupils of both sexes and included some whom teachers described as having excellent academic potential. (p.55.)

It is difficult to separate out and identify individual social factors affecting pupil views on their school experiences. However, Raphael Reed (1998) argued that the intersection of gender, class and ethnicity on national patterns of performance is highly dubious:

...concealing sound markers of social differentiation and undermining the apparent validity of a more radical critique of gender performance in specific social contexts. (Raphael Reed, 1998, p. 57.)

It is these markers of social differentiation that are the focus of my research and the lens I use is that of gender.

In my research I want to explore pupils' experience and understanding of their school science experiences. In this chapter I examine research that informs how to approach and understand the *relationship between gender and attitudes towards school science*. Section 2.2 considers gender as a social force that shapes attitude formation. Within this section research on the processes of socialisation out-of-school and within school (and issues associated with the hidden curriculum: stereotyped roles, textbooks, teacher expectations, teacher attitudes and the representation of science) is presented. There is also a consideration of how changes in the teaching and learning environment allow the effects of the hidden curriculum to be revealed. Section 2.3 investigates briefly whether the type of school attended has an effect on attitude formation. Section 2.4 examines research evidence for gender differences in attitudes towards science.

2.2 Understanding gender as a social force – pupils' attitudes to science

During the 1970s and 1980s research focused on pupils' attitudes to science learning as a key factor influencing subject choice and achievement. In Gardner's (1975) review of gender differences in attitudes, factors associated with 'social forces' were identified. He suggested that these operated

through books, parental behaviours and interests and through teacher expectations of girls and boys. Other research has also shown that social factors played a part in the differential uptake in science (Kelly, 1981a; 1987; Manthorpe, 1982; Smail, 1984; Harding, 1986a). Whitelegg (1992) reported similar findings in her research review. Research in the UK and worldwide at this time also tried to identify the factors affecting pupils' attitudes to science education from a gender perspective. (Key among this research was Gardner, 1974 and 1975; Kelly, 1981a, 1982, 1987; Harding, 1983 and 1986; Kahle and Lakes, 1983; Erikson and Erikson, 1984; Smail, 1984; Smail and Kelly, 1984; Harvey and Stables, 1986; Whyte, 1986; Johnson, 1987). The research indicated that girls' attitudes towards their school science experiences were significantly less positive than boys' and that gender and attitudes towards school science were related.

2.2.1 Socialisation out of school

Young children can be observed as coming to know and give value to certain traits and behaviours associated with their developing gender and as children grow up these traits often become ingrained. Children therefore evolve a set of values and actions according to their gender and these learnt ways of responding to the world resulting from early socialization processes can lead to different educational experiences in school (Kelly, 1981a; Gott et al., 1985, cited in Watts and Bentley, 1989; Whyte, 1986; and Wilder and Powell, 1989).

An overview of early socialization research can be found in Wilder and Powell's (1989) review of gender research. They argue that the toys boys and girls are given to play with from a very early age are often stereotyped, with boys being given toys such as Lego, building bricks, models, etc., that develop skills that have traditionally been seen as important in science education. Whereas girls' toys, for example dolls etc., often reflect the nurturant role expected of many female members of society. There is evidence to suggest that the hobbies and pastimes of boys outside school give them an initial advantage over girls when studying particular science topics (Gott et al. 1985 cited in Watts and Bentley, 1989). Whyte (1986) explained the superiority of boys in the Maccoby and Jacklin (1975) research review as being due to external factors because of the

differing treatments those children have had in their early years, particularly boys' greater experience with 'tinkering' activities.

Browne and Ross (1991) observed large numbers of pre-school children and reported that from a very early age girls and boys had clear ideas about activities related to their gender. For example they found that in nursery, girls chose to play creatively in the 'home corner', read books or talked with adults, whereas boys tended to opt for more constructional activities. Thompson (1994) researched pre-school children's communication styles and found that whilst completing a jigsaw activity girls more than boys were likely to talk about the processes revealing uncertainties with activities; but there was no difference in their ability to solve the puzzles. Adult interpretations of these girl/boy communication behaviours either in help-seeking or in observed outdoor play led them to suggest that girls were more timid and boys were more dominant and confident, and that *these perceptions may lead to subtle shaping of children's self concepts*. Browne and Ross (op. cit) found that at infant school even though girls and boys played with Lego, the objects they made were very different, girls made houses and boys made more mechanical objects. The boys' models incorporated moving parts and focused on movement and balance whereas the girls' models tended to support more social play. Kelly (1981a) argued that:

If the two sexes enter school with different past experiences, different knowledge, different interests, different attitudes and different expectations it is by no means obvious that the same treatment will have the same effect on them. It may be that treating girls and boys identically in school will serve to accentuate rather than diminish the existing differences. (p. 31 – 32.)

Kelly (1981a) also discussed the child rearing process and suggested that masculinity was associated with independence, self-reliance, strength and leadership, whereas femininity was associated with conformity, passivity, nurturant behaviours and concerns about people. The impersonal nature of much of school science does not fit well with this notion of femininity. Kelly (1987) also stated that women and girls viewed the world differently from men and boys and that an understanding of these differing perceptions led to some changes in science teaching in the 1980s that was more accommodating towards the world view of women.

Girls' and boys' reactions to the sciences in school have been extensively researched (Harding, 1979; Johnson and Murphy, 1986; Kelly, 1978, 1981a, 1982, 1987; Wilder and Powell, 1989; Head and Ramsden, 1990; Murphy, 1991; Beyer, 1992; Staberg, 1994). A general consensus has been reached that socialization outside of school and the way that science was presented in school were key factors affecting girls' and boys' attitudes towards their school science experience.

Large-scale surveys such as the first IEA survey reported in Kelly (1978); the NAEP surveys (Hueftle et al, 1983; Kahle and Lakes, 1983) and APU surveys (Johnson and Murphy, 1986) consistently found that boys participated more than girls in out-of-school science related activities. Johnson and Murphy (1986) reported from the APU surveys that there were performance differences in favour of boys when using some particular measuring instruments and that these differences were quite marked by the age of 11. This difference was influenced by the fact that more boys reported out-of-school experiences with the particular instruments or with similar instruments used in the tests than girls. It has been well established that boys' and girls' experience of different out-of-school activities affected their subsequent interest and choices in science (Gardner, 1974; Hueftle et al., 1983; Kahle and Lakes, 1983; Lie and Brynhi, 1983; Sørensen, 1985; Parker and Rennie, 1986; Johnson and Murphy, 1986, Sjøberg and Imsen, 1991).

During Key Stage 3 at ages 11–14 gender identity development reaches a crucial stage. Gardner (1998) suggested that puberty was the time at which there is the most extensive shift in self-definition therefore there are many changes in personal interests. The way we conceptualise who we are affects the types of activities we engage in. Defining the self as male or female sets developmental processes in motion which have wide ranging implications for ways in which we interact with others, develop particular interests and abilities and understand ourselves.

In the next section I focus on research carried on within school that considers factors that influence personal attitude formation.

2.2.2 Socialisation within school

Some studies (Kelly, 1981; Smail, 1984; Whyte, 1986; Harding, 1986a; Millman, 1987) looked at *inequality in both the overt processes at work in school and society as well as the 'hidden curriculum'*, to discover whether these were related to the girls and science problem. Whitelegg (1992) describes the 'hidden curriculum' as involving a:

Complex web of taken-for-granted assumptions and procedures that can only be counteracted if there is a great deal of vigilance on the part of teachers and local authority advisers. Teachers need to recognize that they themselves are powerful agents of socialisation, who also bring their own culturally acquired perspectives with them. (p.180.)

Teacher expectation, behaviour and feedback

Teachers' behaviour towards boys and girls has been researched and reported by Galton, 1981; Spender, 1982; Stanworth, 1987; Clarricoates, 1987; Tobin, 1988; and Delamont, 1990. The research found that teachers sometimes spent more time interacting with boys, valued boys' experiences more in the classroom, had higher expectations of boys' success in science studies and generally treated boys more favourably than girls. There was also evidence to show that teachers had lower expectations of secondary school girls than boys (as did parents and pupils themselves), and were more intellectually encouraging to, and demanding of boys (Maccoby and Jacklin, 1974; Matyas, 1985; Spear, 1987; and Wilder and Powell, 1989).

A small scale, but significant study, carried out by Spear (1987) with 165 teachers in co-educational secondary schools in the UK illustrated some of the different expectations that teachers held for boys and girls in science. In the study each piece of written work in science was attributed to both a boy and a girl and teachers were then asked to mark a sample of the work attributed to boys and girls. She found that teachers' rating of 'boys' science work was higher than that of an identical piece of work attributed to a 'girl'. The 'boys' work was given a higher ranking for richness of ideas, scientific accuracy, originality of ideas, interest in subject and suitability for GCE 'O' level courses. 'Girls' written work was only ranked more highly than 'boys' on neatness. The teachers in this study tended to hold higher expectations in terms of science qualifications for boys than girls. Both science and non-science teachers in the study thought that science was more

important for boys, this effect being greatest amongst the science teachers. This finding was supported by Walkerdine's (1989) research, where she argued that her research in maths education showed that even when girls performed equally well as boys, teacher interpretation of their work was less good and unintentionally influenced by the pupil's sex.

Wilder and Powell (1989) reported that some teachers in some schools reinforced the differences between girls and boys which existed before they entered school and this had far reaching effects on pupils' attitudes to school and science in particular. Such teacher effects could lead to some girls feeling 'out of place' in a science laboratory which in turn could reinforce teacher beliefs. If girls felt 'out of place' this could influence their attitudes to science and their view of the subject in relation to themselves.

Whyte (1983) also reported from the GIST project (Smail, Whyte and Kelly, 1982), that teachers' differential expectations of girls and boys impacted on the pupils' levels of confidence. Licht and Dweck (1987) also found:

...that girls relative to boys have less confidence in their ability to succeed in challenging intellectual tasks. (p.96.)

Crossman (1987) and Tobin (1987, quoted in Kahle 1987a) found that science teachers interacted more with boys than girls in secondary school, mainly because the boys dominated in the class and the teacher therefore paid them more attention. Tobin (op cit.) showed that the ratio of girls to boys as target students (students spoken to directly by the teacher) ranged from 1:4 to 1:8. He suggested that male students more often responded to teacher questions (typical ratio 1:8 girl to boy). In doing this science teachers could become obstacles to fostering positive pupil attitudes to school science, particularly for girls.

However (Randall, 1987) found that 12 to 13 year old girls received more feedback from science teachers than boys, although she found that the nature of girls' and boys' feedback from teachers was different. Teachers' feedback to girls in the laboratory and workshop was commonly

associated with helping and encouraging the girls. Teachers responded to girls' extra need for help compared with boys' and appeared to accept girls' lower confidence levels. Dweck, Davidson, Nelson and Enna (1978) had earlier suggested that girls had a tendency to have lower expectations about their ability and boys tended to overestimate theirs. The APU surveys (DES, 1988a, 1989a and b) of the national population (aged 11, 13 and 15 years) in the UK also supported this finding.

The representation of science in classrooms

Results from an empirical study (Mitroff and Kilmann, 1978) suggested that:

Conventional science is strongly masculine in its orientation, reflecting traditional stereotypical male values: it is hard-nosed, objective, and value-free; it eschews the ambiguous, the speculative, the vague, the beautiful and the good. A feminine science in contrast is not afraid of the good, the speculative, the vague or the unique; indeed it openly courts them, openly confronts them, and makes positive virtues of them. (p. 103-104.)

Weinrich-Haste (1981) also argued that the cultural stereotype of science was masculine and identified the following masculine traits associated with science: perceived as a difficult subject, focusing on objects rather than people; and about thinking rather than feeling.

Other research has provided evidence of the way in which both teachers and institutions were implicated in the reproduction of gender differences within the masculine culture of science. Head (1985) argued that adolescence was a key period in the formation of self-identity and peers' attitudes were a major influence on this process. He stated that both genders perceived science as a masculine subject, therefore it was 'more acceptable' for boys to study science as this helped to establish their identity whereas the converse was true for girls. Kelly (1987b) argued that science was described as masculine in four respects: by the number of males participating in science; the packaging and context of the school science curriculum; that male pupils 'took up' both the physical and the mental space in the subject and that there was an inherent maleness about science. She, like Weinrich-Haste, considered that science was a social construct that perpetuated masculine values of objectivity and incorporated little emotional involvement or ethical consideration. The image of science portrayed was not only male but also masculine in the sense of being cold,

unemotional and logical. This perspective on science was supported by other researchers including Kahle et al. (1993), Byrne (1993) and Trankina, (1993).

Bottomley (1979) provided evidence of other gender and science effects. She suggested that girls did not choose physical science because the teachers were predominantly male and therefore there was a lack of positive female role models in science departments. Conversely, the Girls and Science survey (DES, 1980) showed that there was no relationship between the number of female physical science teachers and the number of girls taking physical science. The WISTA project, in Australia (Byrne, 1993) looked at the effect of having female scientists as positive role models on subsequent choice in science. Byrne collected data from science departments of different universities in Australia and the data showed no correlation between numbers of female science staff and the number of enrolled undergraduates. This suggested that the expected positive effect of female teachers and female career role models on girls' attitudes towards science reflected a rather naïve and simplistic view of the problem.

A classic research procedure to elicit pupils' conceptions of scientists involves pupils in drawing their image of a scientist. The results of many studies using this procedure reflected a particular stereotype of a scientist; often a white male with laboratory coat, glasses and invariably bald (Mead and Metraux, 1957; Hadden and Johnstone, 1983; Chambers, 1983; Kahle, 1987; Mason et al., 1991; Tuckey, 1992 and Solomon, 1993). This is seemingly an enduring stereotype as illustrated by the following quotations from 46 and 16 years ago respectively:

The scientist is a brain. He spends his days indoors, sitting in a laboratory... he is so involved in his work that he doesn't know what is going on in the world. He has no other interests and neglects his body for his mind. He can only talk, eat, breathe and sleep science. (Mead and Metraux, 1957, p.387.)

A quotation from a student 30 years later:

Scientists are totally involved in work. Therefore they don't care about appearance. They wear white coats, have beards because they are men. They just seem to care only about their science work... they don't care about meals. Somedays they starve themselves. They walk around with their science brain all day and they've got their laboratories. (Kahle, 1987.)

Jarvis (1996) conducted a two-part study of 134 primary school children (aged 5 to 11 years) from six schools in Leicester, UK, that explored pupils' views of scientists and intervention strategies aimed at broadening those views. *Pupils' views were explored using the Draw-a-Scientist Test (DAST) (Mason et al., 1991) and this would allow results to be compared with other studies.* The Jarvis study also used photographs of men, women, people with disabilities and from a range of cultures and asked pupils to indicate which of these they thought were scientists. The pupils' views were established first, then they participated in an intervention programme and were finally asked to re-draw a scientist. *There were three interventions: the first involved groups of pupils with non-fictional accounts of female and non-western scientists; the second involved pupils in producing creative oral or written accounts based on science experiments; and the third engaged pupils in co-operative group work where they evaluated a non-fiction science book in terms of how they identified with illustrations.* The older the pupils the more stereotypical their images of scientists: *white males with eye-glasses and lab coats, with only five female scientists drawn in the first round of drawings before the interventions. Only four more female images were drawn in the final post-intervention drawings.* The ineffectiveness of this study to address stereotyping of scientists suggests again that pupils' views are much more deeply held than expected and subject to wider social influences.

Both the role of textbooks in reinforcing the masculine image of science, as well as the representation of girls and women in stereotyped roles in teaching materials are reasons given for the alienation of girls from school science (Sjøberg and Lie, 1981; Chambers, 1983; Kelly, 1987; Whyte, 1986; Kahle, 1985). Whyte (1986) stated:

Bias in textbooks, and the lack of a motivating social context are thus two of the criticisms of the way the content of science ignores or bypasses girls' interests. (p.91.)

Hodson (1993) in a later study suggested that examples used in school textbooks often did not fit with girls' interests and therefore these resources did not tend to inculcate interest in science for girls. In many textbooks there were rarely illustrations of people (even males) and this was particularly so in physics books. Even when girls and women were represented in textbooks

(which was seldom) they were represented in stereotypical roles, particularly passive roles and not engaged in scientific activity.

Teaching and learning styles

Some of the other reasons suggested for girls' (and some boys') lack of interest, and therefore engagement with science as a subject, are associated with pedagogical methods used in the laboratory. Girls' lack of enthusiasm towards their school science lessons was often related to the teaching and learning situation being too formal and only associated with the transmission of scientific content. Galton and Eggleston (1979) suggested that the 'informer' (didactic or transmission) method of teaching was the most commonly used in science classes although it was seen to be the least effective. Based on his observations, Galton (1981, p.18-19) identified three teaching styles in secondary science:

- Problem solver, which involves a high frequency of teacher questions and a low *frequency of pupil initiated or maintained activities*;
- Informer, which uses teacher delivery of facts and an infrequent use of questions except to recall facts; and
- Enquirer, which uses pupil-initiated and maintained experiments as well as inferring, formulating and testing hypotheses.

Carré (1981) used the terms 'transmission' and 'interpretative' for teaching style categorisations. The transmission mode teacher believed that knowledge existed in the form of public disciplines and saw themselves as an 'expert' or 'authority' in the subject. Students saw the teachers' main tasks as correcting and evaluating the learners' performance according to the teachers' criteria; saw *the learners as uninformed and for whom access to knowledge would be difficult since learners must qualify themselves through appropriate performance tests*; and that the performances of learners were only valued if they conformed to the criteria of the discipline. Like Galton and Eggleston (1979), Carré suggested that transmission style teaching particularly occurred within

physics lessons. Teachers that taught in this style had a view that the nature of knowledge was a commodity that could be transferred from one 'container' to another.

Girls more than boys showed a preference for more interactive styles of teaching and learning (Ormerod, 1975; Kelly, 1981; Galton, 1981; Kahle and Lakes, 1983). Kahle (1987) suggested that girls preferred the enquirer method, which was more commonly used in biology classes in the US. She also suggested that physics teachers commonly used the other two modes – informer and problem solver. *Kahle argued that many pupils became disinterested when science teaching was too formal and was tied to the learning of facts and principles, theories and laws in such a way that the pupils were left in no doubt that these ideas were absolute facts and incontrovertible.*

Earlier in the discussion of socialization processes it was argued that psycho-social influences are key factors affecting the engagement of individuals in the learning process. These influences (both outside and within school) affect individual and group gender identity development. Individuals learn to behave from a very early age in gender appropriate ways that reflect societal expectations. Woolnough (1994) supported the view that children from a very early age tend to be treated in gender specific ways and an interest in science was sometimes discouraged in girls. Societal effects lead to boys and girls having very diverse experiences, these experiences in turn lead to the development of gendered behaviours and interests. These social experiences affect pupils in schools, for example with girls and boys exhibiting different preferences in learning styles. Head (1985) stressed that school science must change to make it fit better with girls' development. He found that girls and boys demonstrated differences in their approach to work, one difference was that boys were quicker at making decisions than girls. He suggested that girls tended to be neater, quieter, to concentrate more, be more tolerant of routine, more interested in people and better at teamwork. Boys were more erratic, more likely to produce innovative or original ideas and more interested in inanimate objects. He suggested that even though evidence for these factors was often anecdotal, it was consistent. Kruse (1996) in her research supported some of these findings, for

example that girls work in a more concentrated and sharing way and boys were active in anarchic ways.

2.3 Gender differences in attitude – evidence from research

2.3.1 Topic preference and interests

In addition to reporting that boys had much more positive attitudes to science than girls, Gardner (1975) also suggested that these differences were more prevalent in upper primary school than in secondary school. He suggested that sex differences in attitudes started in children's early years. This view was supported by Schibeci's review (1984). Gardner provided evidence that different socialisation practices reinforced personality traits and behaviours that may affect pupil attitudes towards science, for example that boys should be:

...independent, achievement oriented and dominant; females are expected to be socially responsible, friendly and co-operative (p.23.)

Kelly (1982) suggested that the primary school experience was vital in relation to the formation of positive attitudes by girls towards science (and technology). Similarly Ormerod and Wood (1983) (cited in Rennie, Parker and Hutchinson, 1985) suggested that without attention to the primary level:

...secondary science is merely conducting a somewhat forlorn rearguard action to divert girls' interests towards physical science. (p.228.)

Ormerod and Duckworth (1975) and Gardner (1975) reported that the nature of interest in science also differed with boys being more interested in physical science and girls more interested in biological and social sciences. This was supported by Bottomley, 1979; Tamir, 1987; Hadden and Johnstone, 1983; Craig and Ayers, 1988; and Sørensen, 1985. Hadden and Johnstone (1983) provided evidence in their Scottish study that there was an erosion of interest in school science between primary and secondary school and that this was due to girls' more negative attitudes to science compared with boys'. Hadden and Johnstone also found that the first year secondary pupils (1000 girls and boys) they surveyed showed a preference for biology topics over other aspects of the integrated science course they were studying, nevertheless differences between girls' and boys'

attitudes towards their school science courses were only minimally affected by particular topic preferences. They hypothesised that science departments in individual schools may have had a more major effect on pupils' attitudes to science.

Smail and Kelly (1984) found that, in their study of about 2000 pupils for the GIST project, girls of 12 and 13 years old appeared to be more interested in human and natural aspects of science and boys were more interested in technological and physical aspects of science. Saraga and Griffiths (1981); Weinrich-Haste, (1981); and Collings and Smithers, (1984) reported that girls had more negative attitudes to school science because of the perceived lack of real meaning and relevance of school science to them. Findings from the APU analysis of survey data collated from 3400 thirteen year old pupils in 1984 (DES, 1989b), were that the most popular topics with *all* pupils were biological. The least popular responses were associated with abstract statements of physical science concepts. Qualter (1993) found that physical sciences were not popular with either boys or girls. She also found that:

...both boys and girls respond to topics which they see as relevant to their interests; it is therefore the interpretation by the pupils of what is relevant to them that determines their interest rather than some broad categorisation of topics into biological/physical, abstract/application. (p.315.)

Jones and Kirk (1990) explored gender differences to science topics in their study of 500, 15-16 year old pupils in New Zealand and found that pupils were generally interested in technological applications of science that involved people, and where there were gender differences, they were similar to those found earlier by Smail et al. (1982).

The evidence presented here suggests that research in the secondary sector indicates some conflicting evidence about the relationship between topic preference and its impact on pupil attitudes to school science subjects, but there appears to be a consensus which suggests that girls have more positive attitudes to biological and medical applications of science and boys have more positive attitudes to the physics and technological applications (Johnson and Murphy, 1986). Lack of relevance of some of the content of the school science curriculum affected girls' attitudes to

science more than boys'. Boys more positive attitudes towards science in spite of their views of topics could be associated with the representation of science as a masculine subject and this position is related to *gender socialisation practices reinforcing the notion that it is more acceptable for boys to be interested in science.*

2.3.2 Does school type affect attitude formation?

In Coventry where the research was planned the majority of secondary schools are co-educational community colleges but there is one single sex girls' community college. As my research is focused on gender differences in attitudes towards school science I was considering selecting the girls' college as one of my research schools. Therefore, I decided to examine research into the advantages or disadvantages of single-sex or co-educational schools. Some of the research evidence suggested that single-sex schooling for girls provided more favourable learning environments by protecting them against traditional expectations of their appropriate gender roles (Faulkner, 1991; Mahony 1985). Lee and Bryk (1986) argued that the greater proportion of same sex teachers in single sex schools were possibly providing more appropriate role models and they believed this was advantageous to pupils. However this was refuted by other research discussed earlier. Other research (Fisher, 1994) argued that teachers' expectations and attention towards girls was higher in girls' schools. Faulkner (1991) found in her study of 1823 pupils aged between 12 and 15 years that pupils from single sex schools (both girls' and boys' schools) were less negative about the concept of female achievement than they were at co-educational schools.

However in terms of achievement alone, a study of external examination results in England and Ireland in 1992 (Thomas, Pan and Goldstein, 1994) concluded *there were no statistically significant differences between mixed schools and single-sex schools in examination performance in all subjects.*

Cheng et al. (1995) considered the influence of school type, in England and Wales, compared with other factors on subject take-up post 16. They found the most influential factor was relative

success in the subject at GCSE level. Taking previous success into account they reported that boys from all types of school were far more likely to take physical sciences than girls; and contrary to popular debate, *girls from mixed schools were more likely to take physical science subjects than girls from single sex schools* (by a margin of 6%); there were similar findings for mathematics. Girls from single sex and mixed schools were more likely to take life sciences than boys (by margins between 6 - 10%).

An Ofsted inspection report (1996) analysis suggested girls had more favourable attitudes towards school than boys and achieved higher standards than boys and this was a significant factor in school success. They argued that variation between individual schools was dependent on the socio-economic context, the level of parental support and whether the intake was selective. All of these factors may have had implications for academic and educational success:

The comparison of single sex and mixed schools is contentious and very complex; there is no straightforward answer to whether one type of school is more successful than the other because so many variables are involved. (EOC/OFSTED, 1996, p.24.)

The research cited above provides some indicators about the 'school effect' on pupil attitude and achievement but is far from conclusive. Faulkner (1991) stated that:

...any differences demonstrated between the two systems where girls are concerned are, by their very nature, extremely subtle and difficult to measure or define. They stem from pupil attitudes and self-perceptions, and the ethos of the school concerned. The advantages of single sex system for both sexes, therefore depends on beliefs, expectations and attitudes, rather than on obvious differences in achievement or ability. (p. 218.)

I decided to carry out my research in both co-educational and single sex schools because of the findings mentioned above that the effects of the type of school attended did not necessarily mediate attitudes towards school science.

2.3.3 The nature of attitudes

Research continues to indicate that gender socialisation experiences are a key influence on the development of pupil attitudes towards school science. In my research I therefore intend to explore

the factors influencing these attitudes and the processes whereby differences between pupils are established. In this section I discuss some of the difficulties associated with the attitude construct.

General attitudes to school and learners' perceptions of the self are understood to have an effect on pupils' motivation to learn and the amount of effort they invest in learning. Feelings that pupils have in these respects are very important in developing the self-confidence essential to be successful at school. Attitudes to learning can develop as a result of either frustration or *satisfaction with learning experiences, and they can impede or facilitate learning.* Davies and Brember (1996) reported that some educationalists take the view that attitudes are both determinants and consequences of learning experiences and are therefore directly related to learning. The development of positive attitudes towards school and learning are extremely important as educational objectives.

Pupils' attitudes did not feature in the national assessment tests associated with the national curriculum because of the recommendation from the report of the Task Group on Assessment and Testing (DES, 1988b) that explicitly stated:

...that assessment of attitudes should not form a prescribed part of the national assessment system. (Paragraph 30.)

The Task Group recognized the importance of educational aims that related to the development of personal attitudes but felt that information about pupil attitudes was more appropriately placed within the individual pupil's Records of Achievement (RoA). They stated that these RoAs will have been prepared in conjunction with pupils and remain the property of, and confidential to, each pupil.

This situation however was partly counterbalanced by the non-statutory guidelines (NCC, 1989) which suggested that positive attitudes do influence the willingness that pupils show in their interaction with teachers, with objects and in situations and this 'willing participation' is important

to effective learning. Davies and Brember (1996) reported from their research in primary schools that:

...monitoring children's attitudes can be a useful, diagnostic process worth investing some time in, if it reveals the negative or positive feelings children have about specific aspects of the school world and school work. Teachers with this information might be able to encourage positive attitudes as well as cognitive learning outcomes. (p.19.)

There have been many attempts to define the term 'attitude'. Some early work on attitudes was carried out by Thurstone (1929) and Allport (1954, cited in Fishbein, 1967). More contemporary work on attitudes has been carried out by: Hovland, Irving and Kelly (1963); Gardner (1974, 1975 and 1987); Munby (1980); Schibeci (1984); Rennie and Parker (1987); German (1988); Koballa (1988); Zanna and Rempel (1988); Head (1989); Rennie and Punch (1991); and Oppenheim (1992).

Hovland's Learning Theory model (Hovland et al., 1963) argued for a tripartite view of attitudes that separated affective, cognitive and behavioural aspects. There was much overlap between the three dimensions and they argued that affective attitudes could be the root of behavioural and cognitive attitudes, thus suggesting that behaviour is a result of feelings and thoughts and the interaction between the three.

Gardner (1974, 1975) drew a fundamental distinction between 'scientific attitudes' and 'attitudes towards science'. He reported research into school pupils' 'attitudes towards science' as having diverse manifestations such as: interest in science; attitudes towards scientists; attitudes towards social responsibility in science and attitudes towards open-mindedness; honesty and scepticism in science. Gardner (1974) defined an attitude to science as:

... a learned disposition to evaluate certain ways, objectives, people, actions, situations or propositions in learning science. (p. 2.)

German (1988) described attitudes towards science as incorporating attitudes towards the teaching of science, scientific activities, preferences for science subjects, science in school and science for careers. Whereas, in Gauld and Hukins' (1980) review of the literature on 'scientific attitudes'

they suggested that they were difficult to describe as they were very complex. They stated that positive 'scientific attitudes' were a complex mixture that could be said to represent scientific thinking (for example: a respect for logic; the desire to know or understand; a questioning approach; a search for data and its interpretation; a quest for verification) and were cognitive in nature.

Koballa (1988) and Head (1989) suggested that attitudes were learned and therefore desirable attitudes could be taught. They suggested attitudes could be relatively enduring and therefore they were not easy to change. They believed changes in attitudes were not random but they had definite causes. Her Majesty's Inspectors of Schools (1994) defined an attitude as:

...a disposition to think or act in a particular way in relation to oneself and to other individuals or groups in society. Attitudes determine responses to problems, issues and situations. (p.236.)

Views on attitudes as fixed attributes were given by Zanna and Rempel (1988) who regarded an attitude as:

...the categorization of a stimulus object along an evaluative dimension based upon, or generated from, three general classes of information: (1) cognitive information, (2) affective/emotional information, and/or (3) information concerning past behaviours or behavioural intentions. (p. 319.)

Later Oppenheim (1992) cited an attitude as:

...a state of readiness to respond in a certain manner when confronted with a certain stimuli. (p.174.)

These definitions demonstrate the immense diversity of views concerning the nature of the attitude construct. Attitudes are described sometimes as essentially cognitive in nature (Gauld and Hukins, 1980), as having an affective dimension (Manis, 1985) and having both cognitive and affective dimensions as well as behavioural ones (Hovland et al., 1963; Zanna and Rempel, 1988). Other descriptions concern the quality of attitudes as being either fixed (Zanna and Rempel, 1988; Oppenheim, 1992) or as dynamic (Gardner, 1974; Manis, 1985; Koballa, 1988; Head, 1989; HMI, 1994).

Ormerod and Duckworth (1975) reviewed much research on attitudes. They refer to the difficulties of attitude measurement within social science type studies because of the range of variables affecting attitudes. They refer to the multidimensional nature of influences on attitude such as sex, age, social climate, verbal and non verbal aspects of convergent thinking ('intelligence'), divergent thinking ('creativity'), personality etc. and suggest that each piece of research can focus on one or two of these 'cells', but that the influence of other factors cannot be ignored.

I recognised that attitudes are dispositions with cognitive, affective and behavioural components but was interested in the research to focus on the affective aspect of attitudes. Affective attitudes are key because they influence personal and social decision-making as well as having an effect on pupils' dispositions towards school science. Attitudes are not single unitary constructs but have a number of sub-constructs that I wish to explore in my research. In clarifying my definition of attitudes I drew from the various positions and decided to explore a number of sources influencing pupils' attitudes towards science in school. Some of the sources of influence I want to explore are pupils' views of their ability in science (their self efficacy), pupils' preferences in relation to topics and science activities, ways of working in school science, their views on science as a school subject and trends in girls' and boys' perceptions of their school science experiences over time.

2.4 Summary

An examination of the literature indicates that there appears to be some conflict about the understanding of the relationship between the terms attitude and gender. These terms are understood by some to be fixed attributes of individual pupils and by others as dynamic processes that affect pupils' engagement with and achievement in school science. I argue that the interactive processes between pupils, their self-image and school science is a continuous one and is likely to change throughout the research period. Within this situation, my perspective on the meaning of the terms gender and attitude as subjectivities that are multiple, fluid, complex and contradictory processes, having both emotional and cognitive components and being mediated by psycho-social

influences and the self. I therefore planned to explore pupils' attitudes as developing dispositions towards school science. In my interpretation, pupils' attitudes to their school science experiences are linked to a range of influences both in school and out-of-school, as discussed in this chapter. The consequence for my study of understanding and evolving gender development as dynamic is that a snapshot of attitudes will not help understand how attitudes influence post 16 choices. Therefore I decided to conduct a longitudinal study, across school types, exploring the possible relationship of gender and attitude formation and investigating how the same girls' and boys' attitudes towards their school science experiences emerged and changed over three, or the compulsory five years, of secondary schooling. In this research I am endeavouring to understand the development of pupil dispositions in relation to school science and to follow this effect over several years. Gender is embedded within this process.

Chapter 3 Methodology and research design

3.1 Methodology

Davies (1989) argued that individuals are not unitary and are not socially constructed to give a fixed end product, but are complex and changing constantly and these shifts are affected by a variety of influences. Davies (1989) defines these shifts as positionality and this concept explores how individual positions are both shaped by others as well as being self-determined. I argued in Chapter 2 that socialisation both within and out-of-school affects each pupil's positionality and this process passes through a crucial stage during adolescence. Gender positions reflect acceptable and recognizable social identity and pupils' developing gender identity has a powerful influence on the development of attitudes towards and interests within school science.

In this Chapter I argue my methodological position, the main features of the research methods and analysis selected together with a discussion of the reasons supporting the selection of the respective methods. *I consider approaches to research design suggested by Denzin and Lincoln (1994), Harding (1986 and 1987), Habermas (1972) and Firestone (1987) most useful to my research.* Denzin and Lincoln (1994) defined research design as a flexible set of guidelines connecting theoretical paradigms to strategies of inquiry and methods for collecting and analysing empirical material. It was essential to situate the research first within an appropriate theoretical framework. *As mentioned previously I found that much of the earlier research on attitudes towards school science lacked a clear theoretical framework.* Before describing my theoretical framework there is a range of vocabulary used in educational research that I wish to clarify. Denzin and Lincoln (1994) described four paradigms dictating research design in the 1990s: the positivist, post positivist, constructivist and critical. Responses to three fundamental questions within any paradigm (*the epistemological, the ontological and the methodological*) can be summarised in a way that supports my theoretical position, but first a definition of these terms is important. Harding (1987) distinguished between research methods as techniques for obtaining data (for example: survey, interview) whilst arguing that methodology was a theoretical framework

employed in the research that affected how the research could proceed; and epistemology was the theory of knowledge that could provide answers to questions about what could be known and about the individual interpretation of that knowledge. *Epistemological issues have crucial implications for how general theoretical structures can, and should be, applied in certain disciplines and for the choice of methods of research.* Habermas (1972) described an epistemological theoretical framework based upon three 'knowledge constitutive interests' - technical, practical and emancipatory; where each 'interest' position reflects what is considered to constitute knowledge and what determines how that knowledge is organised socially. Habermas' technical interest is related to the need for prediction and control and knowledge would be gathered by observation and verification through experiment. There is associated with this position an objective view of knowledge and there is a strong link with the positivist paradigm. Johnston and Dunne (1996) describe assumptions commonly associated with this type of scientific inquiry as:

...logical, systematic and absolute...is presented as the most legitimate way of knowing reality and establishing truth. (p.54.)

Habermas' practical cognitive interest is different from the technical as reality is disclosed subject to:

... a constitutive interest in the preservation and expansion of the intersubjectivity of possible action-orienting mutual understanding. (Habermas, 1972, p.310.)

This position argues for the development of meaning as the attainment of a consensus understanding amongst those involved which in some ways reflects my own position. The final position he describes is the emancipatory cognitive interest that is established by the concept of self-reflection. (p.310.). This position is one where knowledge is regarded as socially constructed but the politics of its legitimation and construction are a continual and central concern. Research carried out from this position explores the social structures that work to maintain and reproduce the interest of the power holders (Johnston and Dunne, 1996).

Traditional epistemologies (like Habermas' technical interest) were seeking knowledge as objective, value neutral, dispassionate and disinterested and in a sense were protected from political

interests and from the social values of the researcher. The positivist paradigm works from within a realist ontology whereby matters of moral or aesthetic significance are not considered, and an objective epistemology where any findings are considered to be 'true'. Harding (1986) argues that positivists claim that this type of knowledge is a part of the 'natural order of things' and describes reality, and that elevating certain types of knowledge like this has powerful social and political consequences. Positivist research relies upon quantitative methodologies like surveys that can verify hypotheses. Johnston and Dunne (1996) suggested that:

...quantitative research methods are not associated exclusively with the positivist paradigm, but they are characteristic of it. (p.54.)

Feminist researchers perceive that traditional research is shaped by culture-wide androcentric prejudices. Harding (1986, 1987) discussed three feminist epistemological positions, empiricism, feminist standpoint and feminist postmodern epistemology. Feminists articulated a methodology at odds with standard revisionist versions of positivism and one that recognizes the centrality of gender in the research act; this is a position particularly relevant to my research. Obviously as with any three epistemological perspectives there are tensions between these positions. Briefly empiricism is based on three principles, firstly that the 'context of discovery' is equally important as the 'context of justification' for eliminating social bias in research. Feminist empiricists argue that these biases can lead to partial and distorted understanding and explanation. Secondly they argue that traditional empiricism accepts that social bias will be eliminated as the research is subjected to rigorous hypothesis testing. Thirdly feminist empiricists hold a contradictory position in that they exhort researchers to rigorously follow existing research norms but also hold that it is these norms that lead to androcentric research results. These norms have been constructed to both prevent scrutiny of culture-wide beliefs in research results and to produce answers to questions asked by men about social issues. This is in conflict with some feminist researchers' views. The standpoint position is different from the empiricist view and supports the notion that:

Men's dominating position in social life results in partial and perverse understandings, whereas women's subjugated position provides the possibility of more complete and less perverse understandings. (Harding, 1986, p. 26.)

Harding argues that a standpoint is a scientifically and morally preferable grounding for explanations and interpretations of social life and nature and that the social identity of the researcher is an important variable in the objectivity of results. This reflects my position as I argue that my social identity inevitably affects data collection, interpretation and analysis. Harding's third position is that of a feminist postmodernist epistemology which is focused on the instability and plurality of subjectivities. This is a move away from empiricism and objectivity towards more relativistic ontological and epistemological positions.

The ontological question relates to the form and nature of reality and what is therefore known about it. This relates to my research and my position has to be clear in terms of whether I believe that social reality is external to the individual or a product of individual consciousness. My research will be based upon my understanding that realities are multiple, mental, social and experientially-based constructions which can be local and specific in nature and that their form is dependent on the individual or group holding that construction. The constructivist paradigm (similarly to Habermas' practical cognitive interest) incorporates a relativist ontology, it supports the notion of multiple social and experientially based realities that could be constructed by individuals and groups and could also be local and specific. The main focus of my research is embedded firmly within the constructivist paradigm. This paradigm has a subjectivist epistemology, such that the knower and the subject create understanding as the study proceeds and the conventional distinctions between epistemology and ontology disappear. The researcher and the researched interact to elicit and refine constructions and these constructions are interpreted during data analysis. Rose (1994) developed the notion of partial perspectives and suggests that an alternative to relativism is:

...partial, locatable, critical knowledges sustaining the possibility of webs of connections called... shared conversations in epistemology. (p.191.)

Working within the constructivist paradigm the terms credible, transfer, dependability and confirmation replace terms like validity and reliability. Denzin and Lincoln (1994) propose that the constructivist paradigm argues for:

...quality criteria that translate...validity, reliability, and objectivity into trustworthiness and authenticity. (p. 480.)

I also draw from Harding's feminist epistemologies as these support a subjectivist position

and recognize the importance of gender in the research process.

Patton (1980) acknowledges that there is a continuum of methods between the quantitative and qualitative paradigms, whereas often the two are assumed to be polar opposites. Quantitative and qualitative research methodologies have their philosophical roots in positivistic and naturalistic philosophies respectively. Qualitative research certainly does not represent a unified set of techniques or philosophies, and indeed has grown out of a wide range of intellectual and disciplinary positions (Mason, 1996). The range of traditions with some interest in qualitative research (for example phenomenology and ethnomethodology) does not neatly dovetail into one set of methodological principles or a uniform philosophy. But generally qualitative research reflects perspectives in which there are beliefs that multiple realities and interpretations from different individuals are equally valid, this philosophy is one whereby reality is seen as a social construct. On the other hand positivist researchers assume a common objective reality across individuals. There are different degrees of belief in these philosophies that are dependent on the researcher's epistemological and ontological positions. The debate between qualitative and quantitative researchers is based upon differences of opinion about what can be known and how best to discover this through the use of either objective or subjective methods. Firestone (1987) used four dimensions to differentiate between qualitative and quantitative research: assumptions, purpose, approach and researcher role.

Table 3.1 Firestone's four dimensions

Dimension	Qualitative	Quantitative
Assumptions underpinning research	Is reality socially constructed?	Is reality sought through facts?
Purpose of research	Looking for understanding	Looking for causes
Approach to research	Ethnographic	Experimental
Researcher role	Researcher immersed in process	Researcher detached from process

The approach I plan to adopt to my research is firmly positioned within the qualitative paradigm. Using Firestone's dimensions to illustrate my epistemological and ontological positions my assumptions, purposes, approach and my role can be more easily explained by his qualitative factors.

3.2 Research questions

These research questions arose from my literature review and my methodological position and the research methods I selected were determined by the nature of my research questions:

- Are there gender differences in pupils' dispositions towards school science and how are these expressed?
- What influences the development and formation of these dispositions?
- How do pupils' dispositions towards their school science learning experiences change through Key Stage 3?

3.3 Methods and research design

I studied literature about the use of quantitative and qualitative methods so that I could make an informed decision as to which methods would be most appropriate for my research. Initially I planned to select two research instruments (survey and interview) to enable me to generate evidence and data consistent with my position. Like Hammersley (1990) I felt that the use of as much data as possible gathered via different methods would allow my research theory to be developed and allow understandings to emerge, consequently I adopted pragmatically the tools that were appropriate to my research context. This approach reflects my attempt to secure a broader understanding of the responses to my research questions. Patton (1980) stated that triangulation contributes to verification and validation of qualitative analysis in two ways, the first as checking out the consistency of findings generated by different collection methods and the second as checking out the consistency of different data sources within the same method. I planned to triangulate by using three different sources of data, the questionnaire, the interview and myself. In practice what often happens is that data collected from different sources or collected by different

methods can conflict. Much literature indicates that different paradigms, and research methods associated with them, are often in conflict with each other, but I argue that the two research instruments I have selected can work together to generate the data and evidence I am searching for in this research. I understand that the questions I ask and their treatment (analysis) will enable this research to fit my personal perspective. I support Lather's (1995) suggestion that the main objective of research should be:

... to maximise the research process as a change-enhancing, reciprocally educative encounter. (p.xiv.)

I selected a survey because I could gather a broad range of data efficiently and could make simple comparisons of large numbers of pupils. I selected interview because my ontological position suggested that pupils' attitudes, interpretations, knowledges, understanding and interactions are meaningful properties of the social world. My research was designed to explore some of these properties. My epistemological position leads me to understand that talking interactively with pupils is the best way to generate knowledge and evidence about gender and attitudes as distinctive responses to the social world. The ontological and epistemological assumptions I made led directly to the methods for this research because they reflect the process of knowledge construction and the importance of gender within this process. My role in this research is to construct a series of events. It is inevitable that I will influence the research process, as it will be me that finally aims to distil a consensus construction of the research.

There are advantages and disadvantages associated with any data collection instruments and using the literature and so I address these concerns next. Hopkins (1985) discussed the main advantages of surveys and pointed out that they are easily administered, quick to complete and, in the school situation, easy to follow up. They permit direct comparison of groups and individuals and provide quantifiable data in a wide range of situations. The data can be used to give a sense of the general and overall position in terms of pupil responses to the survey questions. Other advantages are that in the school situation the response rate can be quite high, 100% in some cases, and surveys are relatively cheap to administer. However, Bell (1987) stated that questionnaires would rarely be

completed by 100% of the population for study and therefore a sample must be taken and care must be exercised to ensure that the sample was a truly representative one. I need to ensure that my survey sample *is representative of school populations within the geographical context of my research* and also that they reflect each individual school's intake in terms of gender. Whilst selecting my sample I need to be aware of issues associated with validity and reliability of the research instrument. The validity of survey data is often criticized. Hitchcock and Hughes (1989) define validity as:

...being concerned with the extent to which descriptions of events accurately capture these events, for example, the extent to which the material collected by the researcher presents a true and accurate picture of what it is claimed is being described. (p.105.)

I have concerns that the depth of penetration of the questions and the type of data gathered by survey can be unsubtle and rigid. Also the highly structured character of quantitative measurement procedures involves the imposition of my assumptions about the social world and consequently reduces the chances of discovering evidence that may be discrepant with pupil responses. Holland, Blair and Sheldon (1995) stated that surveys:

... never provide the kind of richly textured 'feeling for the data' that qualitative methods can permit. (p. 223.)

Sometimes surveys can reify social phenomena by taking certain factors in isolation, e.g. when pupils respond to the question: "Do you enjoy problem solving?" There may be many factors that could affect the response of pupils. The very processes by which pupils' thoughts develop and change *will affect their response: the pupils may respond positively on one occasion, but negatively on another, depending on their perception of the question at that time.* This occurs in any situation in which questions are asked, in a survey the researcher cannot explore individual pupil perception of questions, but during interview further exploration of these perceptions can be made.

There are a number of advantages of qualitative research methods such as interviews. Hammersley, Gomm and Woods (1994) emphasised that interviews paid attention to detail and had the ability to:

... penetrate fronts, uncover meanings and reveal the suitability and complexity of cases or issues. These might reveal conflicts discrepancies, inconsistencies, contradictions, but these things are typical of everyday life. Qualitative research is strong in portraying perspectives and conveying feelings and experiences. (p. 70.)

Disadvantages with interviewing, as seen by some, are that interviews can be imprecise, leading to data that is not too clear and sometimes provide one's own perceptions rather than 'hard' facts. I argue from my position that the quality of data collected during interviews when used in combination with survey data would alleviate some of these disadvantages. I want my research to *explore shared meanings that pupils had about their school science experiences.*

It is important for me to remember that any research is a construction of meaning between the researcher and the researched, as Hammersley, Gomm and Woods (1994) suggested:

The interview, therefore, is not just a device for gathering information. It is a process of constructing reality to which both parties contribute and by which both are affected.
(p. 60.)

3.3.1 Overview of data collection

I felt that I needed to ensure that my interview sample was representative of a larger population across three schools in the City of Coventry and to this end I used a survey. But to address the subtle issues implicit in these research questions I decided to simultaneously interview pupils over either three or five years. The research began with a questionnaire survey of 208 Year 7 pupils from three secondary schools in Coventry. During the same year (1994), 60 pupils across the three schools were given a pre-interview questionnaire and were interviewed. This process was repeated during the pupils' Year 8 with 185 of the original sample being surveyed and the same 60 pupils interviewed. In Year 9, 55 of the same pupils from the three schools were interviewed. Finally, 20 pupils from one of the research schools were interviewed in their Years 10 and 11. An outline of the data collection is presented in table 3.2.

Table 3.2 Outline of data collection.

	Total number of pupils	Number of boys	Number of girls	School Year of pupils	Dates
Survey	208	75	133	7	March 1994
School 1	90	45	45		
School 2	60	30	30		
School 3	58		58		
Pre-interview questionnaire	60	20	40	7	March 1994
School 1	20	10	10		
School 2	20	10	10		
School 3	20	-	20		
Interview	60	20	40	7	March 1994
School 1	20	10	10		
School 2	20	10	10		
School 3	20	-	20		
Survey	185	60	125	8	March 1995
School 1	75	34	41		
School 2	54	26	28		
School 3	56	-	56		
Pre-interview questionnaire	60	20	40	8	February 1995
School 1	20	10	10		
School 2	20	10	10		
School 3	20	-	20		
Interview	60	20	40	8	February/ March 1995
School 1	20	10	10		
School 2	20	10	10		
School 3	20	-	20		
Interview	54	19	35	9	May 1996
School 1	18	9	9		
School 2	19	10	9		
School 3	17	-	17		
Interview School 2	18	9	9	10	May 1997
Interview School 2	19	9	10	11	May 1998

3.3.2 The Samples

Participating schools

I selected three secondary schools in the city of Coventry. Coventry has 20 secondary schools and the three were chosen as representative of the range of educational establishments. All selected schools are over-subscribed and enrol pupils from the full ability range. There is no selection on academic ability and the main criteria for admissions is residency. I worked at the two co-educational schools for a number of years. I felt that my knowledge of the schools, the departments, the curriculum and the pupils would be beneficial. I was working in a familiar environment that provided a distinct advantage for the study, as I was aware of the 'local culture', etc. Smith and Robbins (1984) suggested that this detailed knowledge could help with the analysis of data. Conversely other researchers (Becker, 1970, Delamont, 1981) warned against being too familiar with the centre of study. They suggested that it could be too easy for the researcher to make assumptions about the situation that may lead to some questions remaining unanswered. I was aware of this position and endeavoured to guard against making assumptions. In the 1993/1994 academic year all three schools selected had percentage GCSE grades A* to C scores within 12% of the national average for maintained schools in England and within 8% of the average score for all maintained schools in the city. Before starting my research I received approval for the school-based research from the science advisor for the city, the head teachers and heads of science departments and the pupils at the schools involved.

School 1: is a co-educational comprehensive school and community college. It is in a relatively affluent area of the city, and is a large school. This school is for pupils aged 11 to 18 years with a population of about 1500 pupils. *There is an intake of about 270 pupils per year. The school has specialist Technology status.*

School 2: is an inner-city co-educational comprehensive school and community college. It is in a slightly less affluent area of the city and is smaller than School 1 but otherwise is similar. School 2 is for pupils aged 11 to 18 years with a pupil population of about 1100. There is an intake of about

180 pupils per year. The school has specialist Technology status. Ofsted (1995) reported that the school has a very strong position on equality of opportunity and this is a strength of the school.

School 3: is a girls' only comprehensive school and community college. At the beginning of my research, girls' schools were perceived by some to be providers of more positive science experiences for girls than co-educational schools (Forrest, 1992). Although data presented in Chapter 2 section 2.3, illustrates that school type has little effect on pupil attitude and achievement. *This school has a pupil population of about 900, with an intake of about 170 girls per year. It is the only single sex school in the city and has specialist Language college status.*

The survey sample

I selected one third of each school's Year 7 pupils using pupil birth dates as a random selection device, to maximise the chances that the cases studied were as representative of the whole school Year 7 population as possible. The large numbers sampled by the survey hopefully ensured that they covered the full range of views held by this age of pupil in some Coventry schools. I felt that it was important that the responses of pupils were located within the whole year group. At School 2 the Year 7 school roll register was used to highlight those pupils with birthdays between the 10th and 20th of any month of the year. This provided a sample of 25 boys and 37 girls. The gender balance of girls to boys in the year was equal but this selection technique provided a skewed sample. In order to balance the number of girls and boys in the sample, I added boys and girls whose birth dates fell on the 21st of the month and the 9th of the month until I had a sample of 30 boys. This gave me a sample of 49 girls; I used the same technique to reduce this number to 30 girls. In School 1, I used a similar technique as outlined above to ensure that there were equal numbers of boy and girl pupils. In school 1 the year group was 273, the sample size selected for survey was 45 girls and 45 boys. In School 3, the same technique was employed for selection of girls from the school register. From the year group of 178, 58 girls were randomly selected for survey. The final numbers of pupils selected represented one-third of the intake of each school's Year 7. The total sample was 208 pupils (133 girls and 75 boys, see appendix 1).

The interview sample

The interview sample was necessarily smaller than the survey sample. From the original survey sample (208) five groups of four pupils from each of the three schools were selected. I discussed group structure with Key Stage 3 co-ordinators and/or heads of department in all schools. I wanted to have some single gender groups as an analysis of my literature review led me to believe that under these circumstances the pupils may discuss their views more openly. I also wished to select mixed gender groups to reflect the normal situation in classes at the co-educational schools. There were not always four boys or girls from the original sample in each teaching group and therefore sometimes groups had to be made up of pupils from more than one teaching group; this was caused by the random selection of the survey sample, for example in School 1 there were 45 girls and 45 boys chosen across nine teaching groups. Some groups only had two survey pupils in them and these were paired with two survey pupils from another group to make the interview group of four. I did not want to form mixed groups with only one girl and three boys or one boy and three girls as I felt this might be intimidating for the single girl or boy. I liaised with the teachers involved and asked for the mixed gender groups to be friendship groups whenever possible as I felt that the individuals would be more confident to discuss their thoughts and feelings more openly in friendship groups. Each interview group consisted of four pupils and the group structure is illustrated in table 3.3.

Table 3.3 The number and gender of groups per school

School	Girls' only	Boys' only	Mixed
1 (co-educational)	1	1	3
2 (co-educational)	1	1	3
3 (girls' only)	5	-	-

It was intended that the groups selected in Year 7 would remain the same throughout the whole research period. The pre-interview questionnaire was given to all pupils interviewed.

3.3.3 Methods

The questionnaire

Gardner (1987) pointed out some of the problems associated with the interpretation of data from 'attitude' research. He refers to standard methods of attitude measurement used by educational researchers, i.e. Likert scales and semantic differential scales, based on questionnaires used to gather data on pupils' attitudes towards school science. He argued that they ignore the concept of ambivalence. He defines ambivalence as 'a psychological state in which a person holds mixed feelings (positive and negative) towards some psychological object (Gardner, 1987, p.241). In physical sciences pupils may feel challenged by learning difficult concepts but also may fear failure, so that they have both positive and negative feelings about the physical sciences. Munby (1980) had earlier suggested that the use of these scales led to inconsistent results and lack of reliability. Such scales were also criticised for not exploring pupils' attitudes towards school science but were more concerned with aspects of science in society. Rennie and Punch (1991) also suggested that the development of constructs to represent attitude towards science was one that was particularly problematic. They suggested that attitudes towards science should be able to describe a wide range of associated factors including: science as a discipline; as a school subject; as a view on scientists; as a method of teaching science. In this they were describing how science might be considered. Finally they argued that because of the diversity of possible attitudes referents it is essential that researchers clarified the way in which they defined attitudes. Many years later Osborne (1997) suggested that there was still not a reliable and valid instrument to measure pupils' attitudes towards school science.

In my study I decided to initially use a questionnaire (see appendix 2) to uncover the range of factors that might influence pupils' attitudes. This method would allow me to use a large and representative sample of pupils. I then planned to use those findings as a starting point for my research. I simultaneously intended to address concerns about the validity of such data by interviewing pupils. My understanding is that attitudes have intricate and complex meanings, are

dynamic and occur at many different levels of perception. My view is that attitudes are learned dispositions that are mediated by social influences and consequently are developed by individuals in different ways. *Within the interviews I further hoped to explore reasons and explanations for pupils' attitudes towards school science.* I therefore planned to investigate pupils' attitude formation within their changing and broad perceptions of their school science experiences. Consequently I planned to conduct a longitudinal study.

I am aware that the term 'attitudes' is not a single unitary construct but that it encompasses sub constructs that contribute in varying proportions towards individual attitudes towards school science. Some of these sub-constructs will be explored in this questionnaire namely: what pupils *perceived they were good/poor at (their self-efficacy) and what they liked/ disliked* about school science, topic preferences and preferred ways of working in science. The topic preferences section (or interest inventories) provided a list with a requirement that pupils tick which topics they were most interested in. It can be used to measure interest levels, but these can be said to only provide a limited view of what may be having a formative affect on pupils' views on school science. I used *the questions as indicators of pupils' views to illuminate issues associated with pupils and their school science experiences.* The questions were designed as indirect measures of pupils' views on their school science experiences. The questionnaire was designed in three sections.

Table 3.4 The questionnaire structure.

Section	Purpose
Section 1 (Part 1)	An exploration of pupils' perceptions of their competence in a variety of aspects of school science.
Section 1 (Part 2)	Pupils' liking for school science activities.
Section 2	Pupils' topic preference in school science.
Section 3	Pupils' preferred ways of working.

The questionnaire was distributed to the sample in March of their first year of secondary school (Year 7). This was repeated at the same time during their second year (Year 8). I distributed

questionnaires at the same time each year and to the same pupils. Teachers were given an information sheet to guide pupils' completion of the questionnaire (see appendix 3).

The method of responding to the first section of the questionnaire was critical. In section 1 (the first 20 questions) I used Likert-type scales. I was aware of issues associated with validity and the use of Likert scales. The APU used four point Likert scales (DES, 1984) and Oppenheim (1992) also reported the use of four point scales. On the basis of that research I decided that I would use a *four point scale for the pupils to select from in the first two parts of the questionnaire, rather than the more usual five*. There are limitations associated with not allowing the respondent to answer in a 'don't know' category, but I felt that avoiding the middle response of a Likert scale would remove the possibility of pupils selecting an average response throughout the questionnaire.

For Year 7 and 8 pupils I wanted to use more child-friendly alternatives to a number scale for responses to the survey questions. Davies and Brember (1994) carried out a reliability and validity study on the use of 'Smiley' scales as response instruments in surveys. The 'Smiley' self-report measure had been used because it had been specifically developed for use with younger children by the Junior School Project team to measure children's attitudes towards different aspects of school life and the curriculum (Mortimore et al, 1988). *On the basis of these studies I decided to use Smiley scales in section 1, part 1, of the questionnaire.* In this part of section 1 of the questionnaire (Q1 - Q8) the pupils were responding to questions such as:

How well do you think you will do in science?





Do you think you are good at practical work?

In section 1, part 2 of the questionnaire (Q9 - Q20) the pupils were asked to respond to questions by circling a range of 'buckets', ranging from a full one (very much) to an empty one (not much at all). 'Buckets', like 'smiley faces' were used to make the questionnaire more accessible to the Year 7 and 8 pupils. The pupils were responding to questions such as:

Do you like science?

Do you like whole class discussion?

The items on my scale were scored as follows:

- Most positive response, (smiliest face or full bucket), score 4 ☺ ;
- fairly positive response, score 3 ☹ ;
- fairly negative response, score 2 ☹ ;
- most negative response, (grimace or empty bucket), score 1 ☹ .

In section 2 and 3 of the questionnaire different response methods were used. In section 2 the pupils were requested to tick the topics they most enjoyed in school science from a list of 16 areas normally covered in Year 7 and 8 science. They were not asked to prioritise their choices. I believed that pupils could easily make these choices and that a tick list would be very simple for pupils to use. There was only one revision of the questionnaire for Year 8 (Year 2 of the study) and that was associated with section 2 (topic preference). The pupil response in the first year when pupils were simply asked to indicate the topics they found most enjoyable showed a gender variation with boys selecting more topics than girls. To obtain a more direct comparison the pupils in the second year of the research were asked to tick their eight most enjoyable topics.

In section 3 of the questionnaire (Q21 - Q25) the pupils were asked to tick a 'yes', 'no' or 'don't know' response to a variety of questions about whether they preferred working with friends in science, whether they thought science was a girls' or a boys' subject and whether they thought *science was exciting*. *This use of a three point scale conflicts with my position in section 1 of the questionnaire where pupils were asked to respond on a 4-point scale, without a 'don't know' option.* I felt strongly that the questions in this section were asked in such a way that the majority of pupils would easily be able to make a yes/no choice (i.e. they were simple and accessible).

The questionnaire assumed that pupils understood the questions and vocabulary used. I carried out careful piloting with a Year 7 class in the year prior to starting my research to ensure that the pupils *responding to the survey had a clear understanding of the intent of the questions*. Discussion with the pupils after they had completed the questionnaire led to a revision of one question and to a clearer explanation about the smiley faces and bucket response categories. The question changed as a result of the discussion was initially worded: 'Are you good at writing up practical work?' This question was re-worded to: 'Are you good at writing up what you have done?'

Pre-interview questionnaire

A pre-interview questionnaire (see appendix 4) was distributed to 60 pupils (20 from each of three schools) a few weeks before their interviews were to take place. There were two main purposes associated with this questionnaire. The first was to corroborate data from individual pupils with data collected during group interview. The pre-interview questionnaire focused on:

- Q.1 What pupils liked best.
- Q.2 What they thought they were good at in school science.
- Q.3 Whether they thought they were really good at science.
- Q.4 Whether they found science easy or hard.
- Q.5 Whether science and science lessons were exciting or boring.
- Q.6 How they ranked science as a school subject.
- Q.7 Whether science subjects were more suitable for boys or girls.
- Q.8 *Whether school science would be useful to them for work.*
- Q.9 Was school science important to them.
- Q.10 What jobs scientists did.

A range of measures have been used to try to assess pupils' attitudes towards school science. For example, subject popularity studies (Ormerod, 1971) where ranking of school subjects provides some indication of pupil attitude towards science. In my pre-interview questionnaire pupils were asked to do this in Q.6. The second purpose of the pre-interview questionnaire was to inform interview probes so that participation in out-of-school science activities and their perception of their engagement with these similar activities in school science. In addition I wished to explore whether they perceived they were regularly involved with a whole variety of science related out-of-

school activities. As discussed in Chapter 2 different out-of-school science related experiences impact on pupils' competence and interest levels in school science, so I wanted to investigate *whether there were gender differences in perceptions of involvement with scientific activities both in school and out-of-school.*

The interview

The initial reason for my decision to interview in groups was that the pupils, particularly in Year 7, might have felt less intimidated and more relaxed in these situations, as reported by LeCompte and Preissle (1993). The group interview situation supports interactive debate and would enable pupils to present, discuss and clarify both individual and collective ideas about their school science learning experiences. Some advantages associated with group interviewing are that it is inexpensive, data rich, flexible, stimulating to respondents as it aids recall, both cumulative and elaborative. Burgess (1984) discussed the advantages and suggested there could be some 'respondent triangulation' where statements by individual pupils could be subjected to peer scrutiny. Lewis (1992) emphasised advantages of group interviews as enabling consensus views to be revealed and suggested this may enhance the reliability of pupils' responses. Other benefits of group interviewing are that answers from one participant might act as a trigger to responses of others, giving rise to a range of ideas and expressions. Lewis (1992) suggested that these groupings led to lots of ideas, much debate and lively discussion, and that pupil responses to others in the group led to further refined and developed thoughts. I argue that individual attitudes and their expression do not form in a vacuum and that pupils often need to share others' opinions and understanding in order to stimulate their own.

As Fontana and Frey (1994) reported, group interviewing may affect the validity of the information collected because of having dominant person(s) within the group. An emerging group culture may interfere with individual expression and the researcher may become concerned with controlling group dynamics rather than focusing on the interview. Some pupils will copy other pupils' responses in a group situation but I felt that the increased confidence levels of individual

participants would outweigh this disadvantage. The problem of silent or diffident group members was a concern that I kept in mind, and I felt it was important that all group members had equal opportunities to express themselves without feeling inhibited by other participants, but it was impossible to guarantee that. A pre-interview questionnaire was used to compare individual responses with group responses and in this way I aimed to increase the validity of my interview data.

The group structures used in this research were both mixed and single sex. I was aware that behaviour could be influenced by group expectations and that there may be a position whereby responses of pupils could be affected by the constitution of the group. Interview data cannot be assumed to be 'gender free' as one's gender shapes the way in which the world is seen, as Denzin (1989) noted:

...because interviews are gendered, interactional productions, the information given is itself constrained by the gendered identities that are enacted in the interview encounter. Gender filters knowledge. (p. 116.)

Denzin (1989) went on to suggest that the gender of the interviewer and respondents would make a difference because any interview would be taking place:

...within the cultural boundaries of a paternalistic social system in which masculine identities are differentiated from feminine ones. (p. 116.)

I am aware that I am a part of the research process and my own and the pupils' values, background experiences, different levels of self-awareness and self knowledge, gender, different perceptions about science and subjectivity will inevitably influence the process. During interview the pupils' perception of, and relationship with me as a white, female, older researcher will inevitably influence pupil responses. In order for the interview to be successful so that the interviewees participate effectively there must be a specific focus, but the interview should still have the warmth and personality exchange of a conversation, together with respect for all involved. It is important in my role as interviewer that I do not forget that each of the individuals involved in the research has their own social history and individual perspective on the world. This personal involvement could lead to bias but, like Ofeson (1994), I suggest that the term bias is misplaced. My

subjectivity will be used to guide data gathering and allow me to understand my own interpretations of the research and this will be used as a powerful resource. I will be able to provide *insights from within my research as themes converge and understandings emerge*. I believe that talking with pupils and listening to their voices will provide me with a picture of the complexity of their lives and the way in which their school science learning experiences are a part of this picture. During interview I want to focus on the processes of knowledge generation rather than on fixed outcomes as generated by questionnaire responses. I believe that pupils construct *their own reality and that this knowledge is generated rather than gained through discovery of a pre-existing reality*.

During interview I wanted to explore some of the reasons why I felt, from my own experience in teaching science, and from the research discussions in Chapters 1 and 2, that many pupils, particularly girls, persistently held negative views about school science. In Chapter 2 the importance of a number of factors influencing the nature of pupils' attitudes towards and feelings about school science were discussed. However in a single interview I did not think that it would be possible to address all of these issues as individual items therefore I decided to interview pupils over three or five years.

During interview I asked accessible, open-ended questions (see appendix 5) which provided pupils with the opportunity to respond openly. I did not pose direct questions about teachers in my research, as I did not think that it was ethically appropriate to ask pupils to provide a subjective account about individual teachers. I did expect, however, that by asking questions about group work and class discussions, some pupils' views on their teachers might emerge during interview. Pupils were given time and support both by myself and their peers in the group to provide clear answers. The interview schedule was used as a stimulus to support pupils in reporting their views on school science and their reasons for them and it was used also as a device to engender peer discussion to allow undirected views to emerge.

The interview began with a question asking what they liked best in school science and why? This question was selected as the starting question because I felt all pupils would have something positive to say about school science and it developed one of the dimensions from the questionnaire. The pupils were asked to explain why they liked particular aspects of school science; this developed into a discussion around how the pupils felt their school science lessons could be improved. Another dimension that developed from the questionnaire was to elicit directly from pupils how good they felt they were at science. In order to do this, I asked them to identify what aspects of science they were good at and to say why they felt this. I also asked pupils in the questionnaire whether they found science exciting and during interview I asked pupils to say what aspects of science they found easy, hard, exciting and boring. I asked whether they felt that boys and girls were equally well able to do science and they discussed reasons for their responses during interview. I asked what jobs pupils thought scientists did (both in the questionnaire and during interview) to elicit a level of understanding about their awareness of the depth and breadth of the 'world of science'. I asked pupils about how their lessons were structured and why their teachers used whole class discussions. This was indirectly linked to the questionnaire.

As distinct from the questionnaire, I asked pupils where they would place school science as a subject compared with other subjects, to further assess the level of popularity of science. I also asked a conceptually very demanding question about whether they thought any other factors, outside the classroom affected their learning in science. I discussed with pupils what they expected out of their school science studies as I felt this would indicate how they might approach their study of science and their levels of interest and motivation. To further develop this question I asked whether they felt that school science was important to them. I also asked whether their parents liked science in order to discover whether there may have been links between this and their levels of interest in school science.

During interview I used a variety of additional listening skills including focusing, infilling and explicating, checking for accuracy, identifying clues and indicators. Obviously the use of eye

contact and an awareness of how others were reacting to individual responses were key to understanding hidden meanings. Whilst listening to pupils talking I made notes, using pupils' initials to annotate comments. The tape recording of interview discussions was used as a support when analysing my interview notes, particularly to clarify points and extract quotes. I met with the pupils in a warm and friendly environment (usually a small room with comfortable seating, rather than a school laboratory) so that the pupils felt as confident as possible and hoped that my many years' teaching experience would enable a positive atmosphere to develop. The interviews were held either within the head of years' offices or offices of the science department. Although it was very important to hold interviews in places where there were no interruptions, in large schools this was not always possible.

I wanted the data collection to be consistent so this I carried out all of the interviews myself during the second term of each academic year (in Year 7 and 8). I explained to the pupils that any information shared with me would be treated confidentially and that when information was presented in text I would use pseudonyms to ensure their anonymity.

3.3.4 Analysis

Survey analysis

When analysing the survey data I ensured that accounts of findings were as accurate as possible as explained in section 4.1. It was important that any analysis associated with descriptions of data were justified in the evidence presented by me.

Section 1 of the questionnaire

The survey data was analysed using the Statistical Package for the Social Sciences (SPSS). A detailed analysis was carried out on individual questions. A chi squared statistical test was selected to analyse statistically the pupil responses to questions 1 to 20 of the initial questionnaire. This test was selected as the preferred test for categorical data. The null hypothesis was that there would be

no difference in girls' and boys' views and preferences (as indicated in their survey responses) towards their school science learning experiences. The data from all schools from the first two years of the research programme was collated and examined for gender differences in responses to individual questions. The first purpose of the exploratory analysis was to ensure that the data met certain assumptions necessary for the use of the chi squared test and the second was to seek patterns in the data which may have indicated interesting relationships, i.e. looking for boys' responses increasing and girls' responses decreasing over time and vice versa as these would not be specifically identified using a chi squared test. (See appendix 6 for complete sets of data.)

Section 2 of the questionnaire

The number of girls' and boys' selected topics were counted and ranked from the highest to lowest number of selections per topic. For both years the average number of topics chosen by pupils was calculated. The preferred topics were sorted by gender preference and discipline of science preferred (biological/physical). A scan of the topic preference data indicated a gender difference in the numbers of boys and girls selecting topics of interest. As a result of this, the topic preference data was further explored. I considered if 50% or more of the pupils selected a particular topic then it was deemed to be a 'popular' topic. (See appendix 7 for complete sets of data.)

Section 3 of the questionnaire

The number of responses were counted, and then converted to percentages for comparison by gender. (See appendix 8 for a complete set of data.)

Analysis of pre-interview questionnaires

Pre-interview question responses were also used to corroborate pupil responses to similar questions during interview. The responses to pre-interview questions about pupil engagement with out-of-school and in-school science related activities A were counted, converted to percentages and presented in tables and charts by gender and year. (See appendix 9 for complete sets of data.)

Interview analysis

I listened to pupil responses during interview and made extensive notes, and I also used audiotapes of interviews to clarify my notes and for extracting direct quotations. Immediately post-interview I read my interview notes, reflected on what pupils had stated, and attributed responses to particular pupils, by school, gender and interview number. I tagged pupils (using their initials in my notes) in such a way so that I could identify individual comments if necessary. In the interview groups, if one person initiated a response I would ask all other individual pupils in the group whether they agreed or disagreed with the response. When counting numbers of positive and negative responses to questions I did not make a distinction between pupils who volunteered a view and pupils who nodded in agreement or said 'yes'. When I viewed the data more qualitatively, I separated some individual pupil's views that were unique to them, even if they were partially corroborated by others.

During my interview work I allowed a period for reflective thinking in the immediate post-interview stage together with note making that supported ideas and discussions from the interview. It was sometimes difficult to check all of the information collected during the 45 interviews and inevitably I selected some information from the mass of data collected, which could have resulted in a *distorted picture*. *I ensured that any personal interpretation of pupils' responses remained as close as possible to the pupils' original meanings to avoid any distortion.*

Another concern with the interpretation of interview data was that it could have led to me giving more weight to one position in preference to another. For example, I could have taken one line of

thought that: 'there is a lot of disaffection with science' or I could have taken another line, which stated 'there are a lot of good things going on in science'. These positions are rather simplistic and I would expect during interview to have a continuum of responses from pupils rather than absolute positions. I did a lot of self-questioning about the conclusions that appeared to be emerging from interview data to ensure that any conclusions drawn were accurate representations of what pupils discussed during interview.

When I began to group the interview data I made some assumptions, based on pupils' responses during interview, about the groupings selected. I was aware that some of the pupil responses went beyond the proposed categories and I tried to be as responsive as possible to the data when planning these groupings. Part of the analysis process was the extraction of key themes that permeated many of the interviews. Analysis of these themes over two years enabled me to clarify my understanding of pupils' developing views of their school science learning experiences more clearly.

I decided to use a manual method of analysis rather than a computer sort, following discussions with colleagues and reading relevant literature (Watts, 1983; Biklen and Bogdan, 1992). When I began my research I was not aware of computer programmes for analysing interview data, the only option I was aware of was the 'cut up into folders' approach (Biklen and Bogdan, 1992). When I did become aware of the NUDIST software tool, I felt that I had already analysed the majority of my data using one method and wished to retain that method for my analysis. I initially used pre-specified categories from Staberg (1994) who carried out research in the early 1990s investigating how girls and boys viewed physics, chemistry and technology. Her background, like mine, was in teaching chemistry at secondary school level, she was interested in gender differences in the uptake of some science subjects at Higher Education level and her research was relatively recent (1994). Although her work was carried out in a different cultural context (Sweden) I believe the issues she was addressing were fundamentally similar to my own. Major differences between our research were in the methodology: Staberg used classroom observation and interview, with two classes of

pupils (32 in total) from one school over 3 years, she interviewed teachers and used socio-cultural background information to position pupils; whereas, I randomly selected a larger cohort of pupils (208) from three schools for survey, and interviewed 60 pupils from three schools over three years and twenty pupils from one school over five years. Staberg's categories included the following five areas:

- A. The importance of science, why pupils thought they were learning science, formal statements about any science subjects.
- B. Search for terms used like: 'interested', 'bored', 'relevance', 'dislikes', 'behaviours', 'independence', 'time', 'teacher', 'fun'.
- C. Generalisations such as: boys are..., girls are..., e.g. girls dare not, girls are swots, boys are childish etc.
- D. Comments referring to what they found hard in science.
- E. Views about their own success, teachers' views, options.

I followed the approach used by Biklen and Bogdan (1992) that involved cutting sections of the interview notes and placing them in labelled envelopes. The master pages were photocopied and each phrase or sentence was coded and this was placed in an envelope carrying the appropriate letter indicating the category. This process enabled me to avoid confusion between categories and page numbers and to check back to the original master if the context needed to be clarified. The folders were labelled with the interview number and the category. The interview notes were numbered with the schools in alphabetical order and the interviews carried out were numbered from 1.1-1.5 for school 1, 2.1-2.5 for school 2 and 3.1-3.5 for school 3. Comments were labelled by individual pupil, gender and school. The three schools were identified as C, S or T; a number between 1 and 40 identified pupils; girls were tagged as odd numbers and boys were even numbers. So for example, the label S11 identified school 2, pupil number 11, female; C 6 identified school 1, pupil number 6, male.

The analysis began by taking a folder, reading its contents and looking for the emergence of data that fitted into the pre-existing categories. If there was a large quantity of data in a folder then it

was necessary to generate new sub-categories. This involved intense scrutiny to enable me to judge what categories and sub-categories were appropriate. I also referred to my interview notes and tapes to clarify my understanding. *I was aware that the categories may have forced me to reveal explicit distinctions and therefore I may have been creating meaning by making choices between alternatives.* When I had some understanding of the contents of the folder, I made notes as an aide memoire, and these notes helped me to make connections to comments in other folders. The categories inevitably needed working on and new categories had to be added. The initial sort was taking place at the same time as I was interviewing pupils and therefore the categories were evolving organically.

The search for categories was partly pre-determined by the structure of the interview but was also influenced by the literature (Watts, 1983; Biklen and Bogdan, 1992; Staberg, 1994). As the data was analysed it became clear that Staberg's categories used as an initial guide needed developing further. *The initial categories were not subtle enough to collate the diverse range of data being collected; therefore I decided to carry out a second level analysis of the interview data.* The data was re-organised into three categories. The first data category was a pre-specified category; this category was one, which had been used and/or published previously. Much of the data in this category was collected as direct responses to interview questions. The second and third categories arose from the data rich discussions pupils had in their interview groups. *The volume of discussion was reflected in the numbers of comments made by pupils overall; group discussion aided recall and led to some triangulation of data.* The second category was indigenous; this reflected a classification system used by the pupils themselves. For example, pupils may have categorised themselves or others as: 'girls are brainier' or 'boys are better at science'. Where indigenous categories existed the data analysis involved discovering properties of those categories and offering explanations for their derivation. I also used relevant literature from the literature review to further validate my categories. The third category was classified as the researcher's category; this was created by myself to aid sorting of data that was not either pre-specified or indigenous data. When I asked pupils very open-ended questions such as: how could school science be made better? There

was such a diversity of response some of which could be counted and categorised in pre-specified categories, other data could be described as indigenous category data and finally some data which did not fit into these two categories was grouped into researcher's category data; this data emerged as the interview discussions continued.

Gathered data was loosely quantified in a variety of ways including percentages and numbers of comments made by pupils to enable reporting of findings. As there were an uneven number of girls and boys (40 girls; 20 boys) to explore differences, where possible, I used percentages. In response to a question (*this data was pre-specified data*), for example: "do you think school science is aimed at boys or girls in particular?" A count of the number of pupils stating yes or no was made; if a number of girls made a 'yes' response this number was divided by the total number of girls and converted into a percentage. Another way in which percentages were used were to directly compare boys' and girls' preferences. For example: 10 per cent of boys would have liked to go on more trips; *this percentage reflected the views of two boys; 10 per cent of girls represented the views of four girls.*

I counted the number of comments made in some areas of debate when there were large numbers of comments made. For example: there were 59 girls' comments and 37 boys' comments about practical work. Where there were large numbers of pupil comments made I believe this reflected the level of pupil interest in the subject of discussion.

For indigenous and researcher categories the data was presented with quotations used to either represent a common or an individual view. There was an immense variety in pupil comments; some pupil comments (*a sentence of speech*) included up to five distinctive points whereas others made only a single point; because of this it was impossible to quantify comments as percentage representations. I selected some pupil comments to illustrate popular views and other pupil comments to represent unique views. I did not include all pupil comments/quotations, as this would have made the findings section far too long and rather tedious. I included commentary

about some pupil statements but not on all for similar reasons. I reported the data under theme headings related to the questionnaire and the interview structure.

3.4 Summary

Using the larger scale, broad arena of individual responses from the survey, together with the pre-interview questionnaire, which provided narrow, individual data, I will be able to place individual perceptions and feelings gathered during in-depth interactive interviews in perspective. I selected interview for the main phase of my study because I felt that the focus of my research was going to be based on individual voices, expressed within group interviews, providing me with insightful data. I also intended that during the course of the research the individual voices would not become obscured as I moved from very general quantitative data to more individual narrative data. By studying a small number of pupils in depth in as near as possible to normal settings, I would have a good chance of gathering data that represented pupils' real experiences of school science. My intention was to look for patterns of similarity and difference between pupils as well as to listen to individual voices to consider how dispositions evolved. By interviewing the same pupils over either three or five years it would be possible for me to explore pupils' evolving dispositions in responses to questions asked about their school science experiences. The reflection of individual positions may be difficult to portray because of the complexities associated with those positions.

Chapter 4 Pupils' views and feelings about science in Year 7 and 8

This chapter reports on three sets of data from the questionnaire, the pre-interview questionnaire and from interviews.

4.1 Questionnaire Findings

Table 4.1 Year 7 pupils (1994) and Year 8 pupils (1995) number of questionnaires returned:

School	Girls		Boys		Total response		Percentage response (%)	
	Year 7	Year 8	Year 7	Year 8	Year 7	Year 8	Year 7	Year 8
1	45	41	45	34	90	75	100	83
2	30	28	30	26	60	54	100	90
3	58	56	-	-	58	56	100	97

There was a range of reasons for the lower return rate in 1995. Even though I actively pursued staff and pupils for the responses it was not possible to obtain all of the completed surveys because some pupils forgot to return them and sometimes mislaid them. Nevertheless the response rates were high.

Table 4.2 Year 7 and 8 numbers of pre-interview questionnaires returned:

	Girls	Boys	Total response	Percentage response (%)
School 1	10	10	20	100
School 2	10	10	20	100
School 3	20	-	20	100

4.1.1 Pupils' perceptions of competence and liking for science activities

I anticipated that there would be little difference in response from girls at co-educational school and the girls' only school. I carried out a chi-squared test for difference between girls from both

schools on questions 1 to 20 and found no statistically significant differences. Therefore in carrying out statistical analyses I compared all of the girls with the co-educational boys. In Year 7 the response to the Likert scale (1 most negative – 4 most positive response) were explored and only three out of the twenty questions showed a statistically significant difference between boys and girls (see appendix 6 for a complete set of data.) In response to question 2 more boys (43%) than girls (14%) considered themselves to be **very good at science**. For question 3, nearly one third of the boys (32%) and only 14% of girls indicated that they thought they were **very good at problem solving**. In response to question 18 more boys (61%) than girls (33%) responded that they liked problem solving very much.

In Year 8 there were significant differences in responses of boys and girls to questions 2, 3, 18 and 19. One third of boys (33%) but only 13% of girls considered themselves to be **very good at science**. A higher percentage of boys (25%) than girls (14%) thought they were **very good at problem solving**. One half of the boys compared with nearly one third (30%) of girls responded that they liked problem solving very much. 73% of boys but only half of the girls very much liked making up their own experiments.

4.1.2 Pupils' topic preferences in science

Complete sets of data are given in appendix 7 and a summary of the findings is given here. Year 7 boys made more topic choices (mean number of choices 6.7) than girls (mean number of choices 4.7). In Year 7 girls stated a preference for more biological topics than boys did, these included: *animals; the human body; food; health; environment and plants*. The two preferred physical science topics girls stated a preference for were materials and electricity. More boys stated a preference for physical science topics than girls and these included: *electricity; acids and alkalis; space; magnetism and energy*. Girls' and boys' preferences only overlapped on one physical science topic. Boys preferred biological science topics were narrower than girls but were in common with the girls' preferences, *i.e. the human body; animals and food*.

In Year 8 both boys and girls gave more preferences and the numbers for both were very similar (mean number of choices: boys 7.6, girls 7.3). Year 8 girls indicated that they equally enjoyed biological topics (animals, environment, plants and food) and physical science topics (materials, magnetism, space and acids/alkalis). Boys however still indicated a preference for physical science topics (electricity; materials; acids and alkalis; measuring; forces; magnetism) over biological topics (human body; environment).

4.1.3 Pupils' preferences for ways of working in science and views of science

The Year 7 and 8 the data indicated that the great majority of girls and boys (90% plus) agreed that they preferred to work with friends. Very few girls and boys (around 10%) agreed that science was a gendered subject either for boys or for girls. In Year 7 most pupils (70% plus) agreed that science was an exciting subject. The data indicated that a quarter of girls and boys thought science was boring or didn't know. In Year 8 the majority of pupils (77% of boys and 53% of girls) thought school science was exciting and very few pupils perceived that school science was boring, although the number saying they didn't know increased from Year 7 to Year 8. (See appendix 8 for a complete set of data.)

4.2 Pupils' engagement with science related activities in school and outside of school

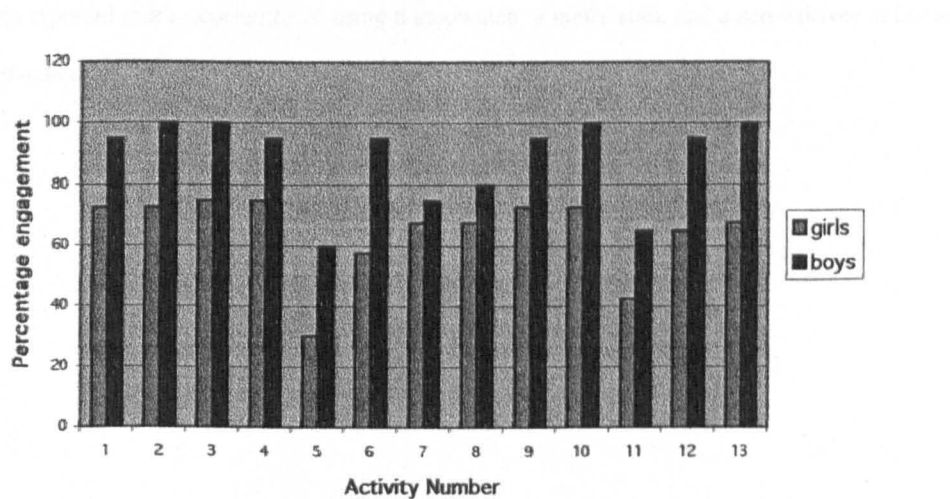
The data collected from the survey was extended in the interviews by asking questions about science-related experiences inside and outside school. The responses to pre-interview questions about pupil engagement with out of school and in school science related activities were counted, converted to percentages and presented in tables and charts by gender and year.

4.2.1 Experience of using equipment and instruments in school

Table 4.3 The percentage of positive responses for Year 7 and 8 pupils.

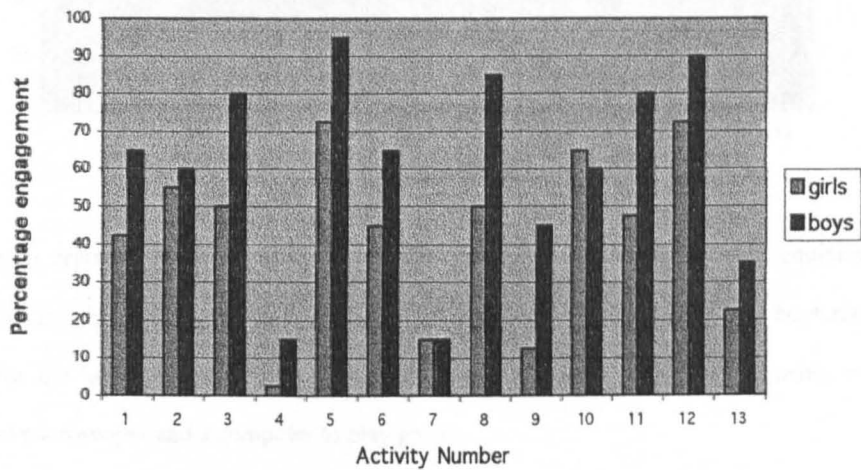
Equipment/ instrument	At school		At school		At home or out of school		At home or out of school	
	Girls		Boys		Girls		Boys	
	Year 7	Year 8	Year 7	Year 8	Year 7	Year 8	Year 7	Year 8
1. a hand lens	73	95	95	90	43	53	65	60
2. a thermometer	73	93	100	90	55	68	60	50
3. a stop watch or clock	75	98	100	85	50	63	80	75
4. a spring balance	75	95	95	80	3	5	15	15
5. a computer to play games	30	35	60	55	73	93	95	90
6. a computer to do things other than play games	58	83	95	80	45	53	65	75
7. a dropper	68	85	75	75	15	23	15	20
8. a compass	68	83	80	70	50	50	85	70
9. a metre stick	73	93	95	85	13	20	45	30
10. a measuring cylinder	73	90	100	75	65	78	60	65
11. a screwdriver	43	55	65	55	48	83	80	85
12. weighing scales	65	78	95	85	73	93	90	85
13. a microscope	68	83	100	90	23	30	35	35

Figure 4.1 Year 7 percentage responses to use of equipment and instruments in school by gender.



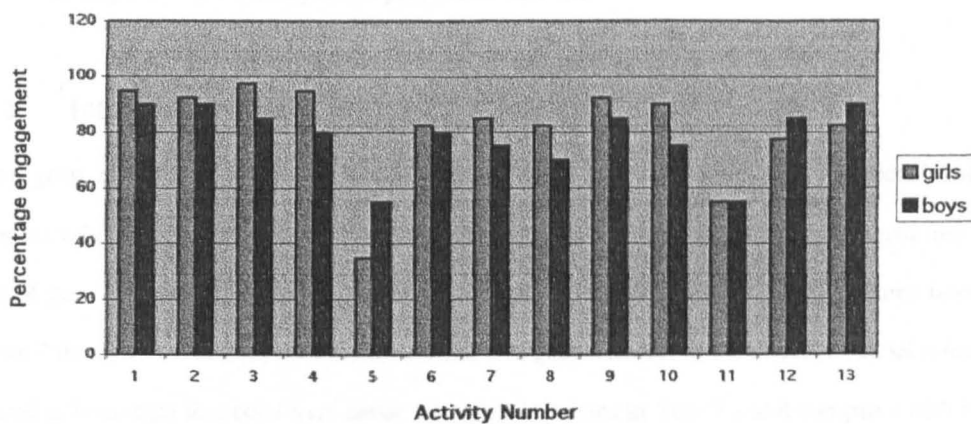
Although all pupils followed the same science curriculum, girls reported less experience than boys using equipment and instruments in school. At least 30% more boys than girls reported using weighing scales and a microscope and a computer both for games and other things.

Figure 4.2 Year 7 percentage responses to use of equipment and instruments at home or out-of-school.



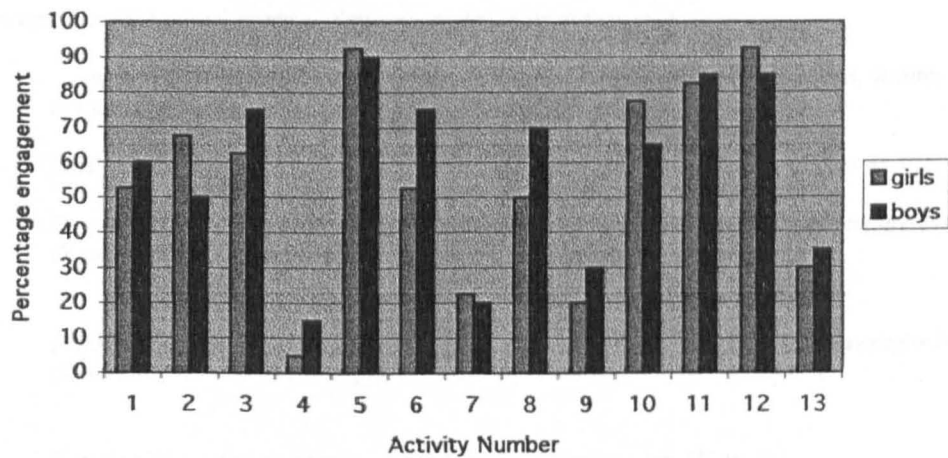
At home or out-of-school girls reported less experience than boys in using 11 out of 13 of the pieces of equipment and instruments. Using a dropper and using a measuring cylinder or jug were the two activities that girls reported more experience of than boys. At least 30 per cent more boys than girls reported more experience of using a stopwatch, a metre stick and a screwdriver at home or out-of-school.

Figure 4.3 Year 8 percentage responses to use of equipment and instruments in school.



Year 8 girls reported more experience than boys on nine out of 13 articles of equipment and instruments in school. This was in marked contrast to Year 7 findings. Girls and boys responded equally for the use of a screwdriver. Again boys reported more experience of using weighing scales and microscopes and a computer to play games.

Figure 4.4 Year 8 percentage responses to use of equipment and instruments at home or out-of-school.



Boys reported more experience than girls in using eight out of 13 pieces of equipment and instruments at home or out-of-school, a small reduction compared with Year 7 findings. Girls reported more experience of using a measuring cylinder as in Year 7 but also reported more

experience of using a thermometer and marginally more experience than boys in using a dropper and weighing scales and a computer to play games at home.

4.3 Interview findings

The great majority of pupils (70% and 83% of girls; 65% and 90% boys in Year 7 and 8 respectively) thought that girls and boys were equally good at science in school. A small number (4) of girls in Year 7 and 8 thought girls were better at school science than boys. Three boys in Year 7 thought this too, but no Year 8 boys felt that girls were better than boys at school science. Three girls thought that boys were better than girls at science in Year 7 and 8 compared with four boys in Year 7 and two boys in Year 8. This data indicates very low levels of gender stereotyping associated with ability in science. Most pupils (100% and 95% of girls; 90% boys in Year 7 and 8 respectively) thought that school science was aimed equally at girls and boys. This data suggests that most pupils did not believe in the stereotype that boys are better at science than girls or the perception that science was a masculine subject. Two boys suggested that school science was aimed more at boys than girls in Year 7 and 8. No girls suggested this in Year 7 and two girls suggested this in Year 8. Pupils' comments summed up a common sense view on whether girls or boys were better at school science. Some examples of what they said:

...can only get better if you work hard and pay attention and ask questions, it does not matter whether you are a boy or a girl. (Year 7)

Girls and boys are the same at science it's a case of who pays attention. (Year 8)

Boys and girls do the same at science depends on how hard you try, girls mature faster. (Year 8)

Science is aimed at girls and boys, they wouldn't teach boys and girls if it wasn't for both. (Year 7)

Can all be the same at science, depends on how hard you try. (Year 8)

During interview there were many comments made by both Year 7 and 8 girls and boys suggesting that gender stereotypes and masculine images of science were held by a number of pupils; this

reflects more subtle data, which emerged from interview discussion. Some Year 7 and 8 girls' comments:

Boys and girls are the same [at science] but there are more men than women scientists. (Year 7)

Science is boring it should be for boys. (Year 7)

Sometimes boys are better than girls, sometimes girls are better than boys, but girls are better at writing. (Year 7)

More boys' jobs are related to science. (Year 8)

There are not many female engineers. (Year 8)

Some Year 7 and 8 boys' comments:

No difference between boys and girls but you don't see women under cars. (Year 7)

Girls and boys are the same at science; some girls may (even) like science. (Year 7)

Some parts of science aimed at boys and some parts aimed at girls, can't think of any examples. (Year 7)

In science films there are more men than women. (Year 7)

It's about boys, electrical stuff, girls like all subjects. (Year 8)

A few girls and boys agreed that gender stereotyped images of science were exhibited by many TV programmes but they felt that these and other media stereotypes were associated more with earlier generations than with their own.

Girls could do better if they had more chance, in the past women and girls were seen as second class. You do not see many girls on building sites, if there was more respect for women on the sites they would get better at it... (Year 7)

Discussions during interview reveal that equal opportunities awareness and policy development had begun to challenge some gender stereotypes in schools. There was a prevailing notion among pupils interviewed that gender stereotyped behaviours had more negative effects on earlier generations than their own.

The following comments illustrated that girls and boys can be perceived as being good at school science but perhaps for different reasons. Seven pupils (4 girls, 3 boys) suggested that boys were better at science than girls. Some girls' comments that illustrated stereotypes were:

Boys better at mechanics. (Year 8)

Boys are better at working out things. (Year 8)

Boys better at some parts - mechanical, girls are more mature they take things more seriously. (Year 8)

Boys like experiments more than writing, girls are better at writing because they do not mind it. (Year 7)

Boys always did it [the experiment], we watched, boys liked experiments more than copying. (Year 7)

Boys have a giggle and mess around. (Year 7)

Girls concentrate more on their writing... (Year 8)

This comment was related to sex education lessons:

Boys are embarrassed, they are more immature [than girls]. (Year 7)

There was only one comment from all pupils interviewed, which stated that girls were better at science:

Girls are better at science because boys mess around, girls are more sensible. (Year 8)

Some boys' comments:

Boys are better at experiments, boys mess around and are silly. (Year 7)

Boys are better because they are more interested in technology, transport, planes and cars. Girls don't understand science as well as boys so they don't do so well in tests, maybe because they are not so interested in it. (Year 8)

Boys are better at electricity, girls are better at bookwork. (Year 7)

The boys want to show off because their friends are around. (Year 7)

The following comments illustrated a perception that girls tended to be more compliant than boys and were content to complete work whether or not they had any interest. Another point illustrated by these quotes was that girls were 'neater' suggesting that some girls wished to please 'their audience' more than some boys. Boys' comments:

Girls take more interest in things, boys mess around. (Year 7)

[Science is] aimed at both [girls and boys]. Sex education is aimed at boys, a lot of girls' parents talk to them about things that happen in life more, girls don't show if they don't like a subject because they just do the work. (Year 7)

Girls are neater, boys are better at experiments, lots of boys mess around, boys are more up front, girls get on with their work. (Year 7)

Girls are better at writing, bookwork and are neater; girls get on with it, they have more interest and they like all subjects. (Year 7)

Girls don't show if they don't like a subject because they just do the work. (Year 8)

Girls were also seen by some to be less likely to take risks in practical situations:

Girls are scared of the Bunsen burner. (Year 7)

There were other comments referring to girls' approach to practical work in science, for example: being squeamish about animals and being concerned about spilling liquids:

Girls go to the teacher with a cracked nail, they're supposed to be more mature; science is about boys, electrical stuff, mechanics, girls like all subjects. (Year 8)

The following comments demonstrate that there are always exceptions in pupils' perceptions.

Some boys are interested and work well. (Year 7)

Boys prefer not to do science, they could be good. (Year 7)

Not all boys are immature. (Year 8)

Pupils were asked whether they thought they were good at science. Their responses are presented graphically in figures 4.5 and 4.6.

Figure 4.5 Year 7 percentage response: Are you good at science?

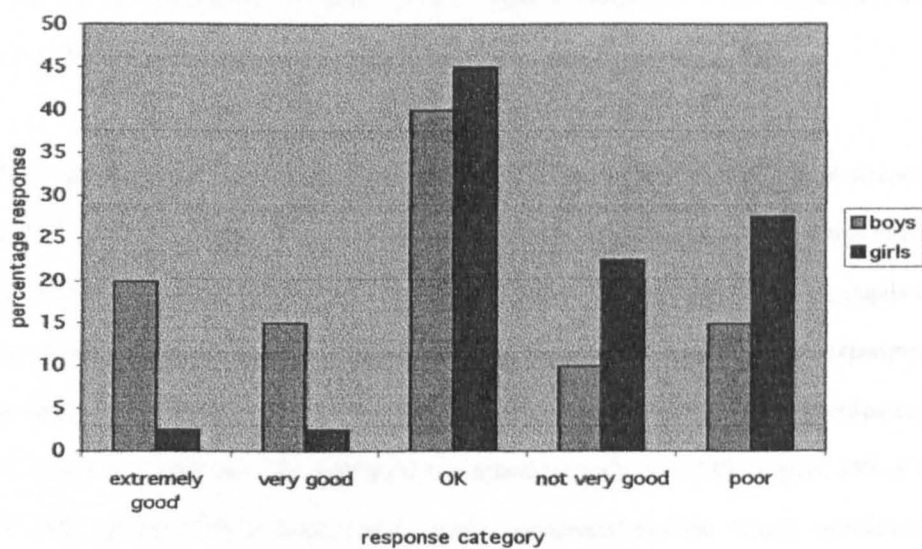
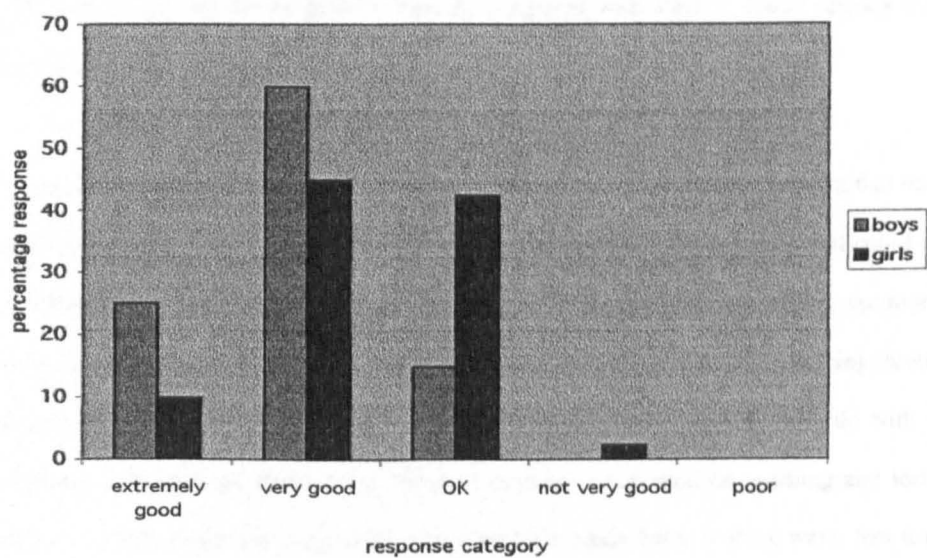


Figure 4.6 Year 8 percentage response: Are you good at science?



Figures 4.5 and 4.6 indicate that in Year 7, 35% of boys compared with only two girls (5%) responded that they were 'extremely good at' or 'very good at' science compared with 50% of girls and 25% of boys responding in the two negative categories. But by Year 8 there had been a large

shift with 85% of boys and 55% of girls responding in the two most positive categories, no boys and only one girl responding in either of the negative categories. This contradicts overall comments made by girls and boys that they were equally good at science in school.

In Year 7 and 8 over 80 per cent of pupils responded during interviews that school science was important to them. 83 per cent of girls in Year 7 and 8 suggested that school science was important to them compared with all of the boys. There were many common responses from pupils about what aspects of science lessons they liked best which revealed that practical work/experimenting was the most popular by far and there was a slight increase in popularity in Year 8 compared with Year 7. Many pupils felt that they were good at practical work (Year 7: 63% of girls, 75% of boys; Year 8: 58% of girls, 65% of boys). Many pupils commented that the writing associated with school science (worksheets, working from booklets, copying and work from text books) was very boring in Year 7 and this reduced in Year 8. Many pupils also considered that the writing work associated with school science was very hard (Year 7: 65% of girls, 50% of boys; Year 8: 35% of girls, 50% of boys). Far fewer girls in Year 8, compared with Year 7, found science writing activities hard.

There were some gender differences with respect to how Year 7 and 8 pupils thought that science could be made better. There were eleven areas that individual boys' suggested that could make science better, these included making more things; less demonstrations; less writing up; more on the history of science, technological developments, and inventors, more problem solving; research; biology; work with engines; better equipment. The boys' responses were more to do with what was included in the science curriculum. Girls in contrast commented on teaching and learning approaches. Girls for example suggested science could be made better if there were: less teacher talk (23%), more presentations (13%), female teachers for sex education and more relevant/ useful topics (7.5%). Individual girls would have liked: more independence; to study more new topics rather than repeat primary science topics; better teacher feedback; and more group work. A few

girls would like to have had more homework, more opportunities to design their own experiments and teachers to use simpler vocabulary.

The majority of pupils considered that there was no relationship between how good pupils were at science and their gender. A small number of boys and girls still held the view that that either 'girls were better' or 'boys were better' at science and that school science was 'aimed more at' boys than girls. There were some gender differences in pupils' perceived confidence in how good they were at science, but there were within gender group exceptions too. In Year 7 boys generally responded more positively than girls, but there was one girl who felt she was 'extremely good at' school science and three boys who felt they were 'very poor at' school science.

Inevitably during interview pupils discussed issues concerning their school science experience that had not been directly asked about. If pupils responded about particular topics more than a very few times I collated their comments and produced sub-categories of data (there were two sub-categories of emergent data: teachers and time). The responses in this section have emerged from interview discussions.

Pupils' views of teachers

Individual comments from pupils suggested that in their view science teachers should: spend less time demonstrating experiments, explaining work, providing solutions to practical work before pupils have done it and talking to the class as a whole. Also they felt that teachers should not talk whilst they are writing on the board. Pupils wanted teachers to be available to offer more help during lesson time and to provide more opportunities for class discussion. Year 7 and 8 girls' comments illustrating these points:

If something is really difficult and the teacher is busy you can get your work wrong...

Don't like it when the teacher shows us what to do because we know what is going to happen.

Teacher does most of the talking, we'd like to join in more...listening to the teacher for a long time is boring.

It's hard coping with teacher going on a bit at the beginning of lessons leaving not enough time to do things properly.

Sometimes when I'm stuck [like doing magnetism or electricity] the teacher is too busy with the naughty pupils.

[Need] more interesting discussions and feedback.

More time to do experiments, less teacher talk.

All of these comments provide further evidence that girls tend to focus on teaching style and learning issues and that these can negatively affect their participation in school science.

Year 7 and 8 boys also commented about teachers but to a far lesser extent than girls:

Too many teacher demonstrations, boring just sitting and writing up.

If the teacher puts results on board what is the point of us doing the experiment?

A small proportion of boys also commented on the pointlessness and boredom of some science lessons. Some Year 7 and 8 pupils wished to have more extrinsic motivation:

We never get commendations, so we don't try hard because there is no reward. (girl)

More commendations. (boy)

Girls discussed teacher related problems with their school science experiences that were not mentioned by boys. A few girls commented that they would have liked more fun and enjoyable experiences in their science lessons as well as more enthusiastic teachers. One girl felt that teacher feedback was not very useful and a couple of girls mentioned the embarrassment associated with speaking out in whole class discussion time. Two girls mentioned that the relationship between teachers and pupils could have been better; and one suggested that science was better if she liked her teacher. One Year 7 girl's comments:

Teachers and pupils need to get on better together, it's not good when the teacher shouts because pupils muck around; it would be good if the teacher stopped the whole group and answered questions that were always cropping up in one go.

I prefer the feedback in English because there is always a comment rather than just a number out of ten.

It's good when the teacher makes it fun for you and you enjoy it.

Other Year 7 and 8 girls commented:

Needed more chances to say what they felt; most pupils are too shy to ask and are worried about getting things wrong because people may laugh. It's a bit embarrassing talking out in class.

If you like the teacher, like the work, like the lesson you get good at it.

Helpful if the teacher walked around the classroom because it is embarrassing to put your hand up.

Teachers should treat us as equals rather than use discipline, they could use more humour and still be strict.

Make it more enjoyable, a more enthusiastic teacher.

Would like the teacher to be more enthusiastic and help more.

One girl suggested that she:

Would respond better to a sixth form helper than to teacher.

Another Year 8 girl said:

Feel intimidated by the teacher.... about knowledge.

One group of four girls would have liked the opportunity to provide reflective feedback, about what they enjoyed or otherwise, to their teacher after completing topics.

Maybe teachers should ask pupils what they think, whether they enjoyed the work and what they should study next term.

Six Year 7 girls discussed the inadequacies of teacher explanations:

Teacher needs to explain more for homework, quite a lot is difficult.

More teacher explanation about how to write up.

Better teacher explanation, only demo experiment and do predictions if it is complicated.

Hard to understand clearly what the teacher means.

Teacher needs to be better at explaining things more simply.

You don't have to think and you don't have to know it the teacher tells you in the end.

Only girls mentioned having problems with teacher explanations.

Many of these girls' comments about their school science experiences related teachers' behaviours to their feelings about the subject.

Pupils' views on time

In Year 7 more girls (30%) than boys (10%) mentioned problems with time in science lessons. Teachers, as mentioned in the previous section, exacerbated some of the problems. Some Year 7 girls' comments:

Better if we had more time there is often not enough time to finish our work.

There is always a rush for equipment.

Better if the lessons were longer because we'd have more time to do the experiments.

Then there's not enough time to do the experiment properly.

When the teacher goes on and on about what we have to do when we've understood it after the first explanation.

If the teacher talked less we would have time for practical.

Another Year 7 girl suggested that:

Going too fast made science hard.

And three others would like to:

Work at their own pace.

These findings reflect those of Boaler's in her study (1998) of girls in maths top sets. A small number of boys, like girls, felt they were rushed in science at school.

Need to spend more time on topics rather than jumping about. (Year 7)

In Year 8, four boys and three girls mentioned that they would have liked longer science lessons to have time to plan practical work and complete it thoroughly. For example one boy stated that:

Need more time to think about the practical work to do it well. (Year 8 boy)

4.4 Summary and discussion

The data for pupils' perceptions of competence and liking for science activities indicated clearly that girls and boys responded similarly to the majority of the questions asked. In Year 7, more boys responded positively than girls to being very good at science and problem solving and really liking problem solving. In Year 8 pupils' responses were similar to those given in Year 7, with boys responding more positively than girls about the same aspects of science. Additionally, Year 8 boys responded more positively than girls about making up their own experiments.

The data indicated a gender skew in topic preferences in Year 7. More of the girls surveyed expressed preferences for biological topics over physical science topics and more of the boys expressed preferences for physical science topics. In Year 8 the data illustrated a change in some of the girls' responses. The girls' preferences were equally split between biological and physical sciences areas, but the boys' preference areas were even more in favour of the physical sciences. However, there were many common selections by girls and boys. In Year 7 the favourite biological science topics (from the top eight topics selected) were animals, human body and food.

The only common popular physical science topic was electricity. In Year 8 the most favourite biological science topic (from the top eight selected) was the environment and the most common physical science topics (out of the top eight selected) were magnetism, acids/alkalis and materials. The topics chosen are ones where there is a lot of practical activity.

Some of these findings reflect those of other research by Ormerod and Duckworth (1975), Hadden and Johnstone (1983), Smail and Kelly (1984), Tamir (1987), Smail (1987) and Craig and Ayers (1988) which showed that there were differences in preferences of girls and boys to specific areas within the science curriculum, with girls having more interest in biological sciences and boys having more interest in physical sciences. Stables and Wikeley (1996) found similar gender differences in terms of biological and physical science preferences. As in my research they found that the differences between the preferences expressed by boys and girls ran along what might be regarded as traditional stereotypical lines. My research indicated some similarities in preferences for biological topics but the boys in my sample did show preferences in physical science topic areas too. Other research by Johnson and Murphy (1986) found that in the secondary sector there was conflicting evidence about these pupil attitudes but there appeared to be a consensus that suggested girls were more positive about biological and medical applications of science and boys were more positive about physics and technological applications of science. Research by Sjøberg and Imsen (1991) also showed the same general patterns when analysing responses to subject area interests:

...the boys are strongly interested in subject matter related to cars and motors, girls are interested in subject matter related to health, nutrition and the human body. (Sjøberg and Imsen, 1991, p. 230.)

Interestingly, Qualter (1993) observed that topics relating to animals and people were not unpopular with boys in her research but proved to be more popular with girls. She found that more abstract areas in science were unpopular with boys, and very unpopular with girls. She argued that maybe the boys viewed physical science topics as more relevant to their future careers. The Assessment of Performance Unit (APU) (DES, 1988a, 1989a and b) survey and Peltz (1990) also found that boys were more interested in aspects of science that corresponded to their possible career needs.

In Year 7 more than fifty per cent of boys selected four topics of interest and more than fifty per cent of girls only selected one topic. By Year 8, more than half of the boys selected nine topics of interest (seven physical science, two biological science) and more than half of the girls selected six topics (four biological and two physical science). The increase in number of selected topics could be attributed to pupils increased understanding of science topics, their level of maturity and confidence in school science as well as other factors.

The majority of pupils in Years 7 and 8 agreed that they preferred to work with friends, did not think science was a gendered subject and found science exciting. The majority of boys found science exciting in Year 8 but the responses for girls had become much less positive, even though a large proportion of girls had responded that they thought they were much better at school science in Year 8.

Key points from the questionnaire results

- More similarities than differences in girl - boy responses.
- Boys rated themselves more confidently in a few aspects of school science than girls.
- Girls preferred biological science topics, boys preferred physical science topics.
- Pupils found school science exciting in Year 7; in Year 8 girls were less excited by school science than boys.
- Pupils agreed that they preferred to work with friends in group work.
- Pupils did not think science was a gendered school subject.
- Interest in science topics increased from Year 7 to Year 8.

In the pre-interview questionnaire Year 7 boys reported a higher level of engagement with scientific activities in school than girls. This position changed in Year 8 with girls reporting a

higher level of engagement with scientific activities in school than boys. This possibly reflected girls increased confidence in their ability to do science. In response to level of engagement with science activities out-of-school Year 7 and 8 boys reported more engagement than girls. Research by Kelly (1987) reported similar findings and she indicated that girls' interests outside the formal school educational environment were different from the interests of boys and this was reflected in girls' reluctance for science study in school. My research findings indicated that this was the case for some Year 7 and 8 girls. The notion that boys and girls have experienced different background activities that may have effects on interest in science has been well researched (Sørensen, 1985, Parker and Rennie, 1986, Whyte, 1986, Kelly, 1987). There is evidence (Gipps and Murphy, 1996), that the hobbies and pastimes of boys outside school give them an initial advantage over girls when studying particular science topics. Murphy and Elwood (1997) argued that differing early experiences of girls and boys could lead to them to respond to, and make sense of, the world differently and this would lead to differences in both what, and how, they learned science in school.

Key points from the pre-interview questionnaire results

- Boys were more engaged than girls in science activities in school in Year 7; in Year 8 this position had reversed.
- Boys were more engaged with science related activities out-of-school than girls in Year 7 and 8.

Data from pupils' preferences for ways of working in science and views on science illustrated that the majority of pupils thought that boys or girls were equally able to do science at school, that science was aimed equally at boys and girls and they preferred working with friends.

Half of the girls and three quarters of the boys responded that they were 'OK', 'very good at' or 'extremely good at' science in Year 7 and this increased to include nearly all girls and all boys in Year 8. The majority of pupils thought school science was important to them. This positive response suggested that most pupils perceived school science as a key school subject. These pupils

had studied science as a part of National Curriculum requirements from their Year 2, as science, maths and English have been the central focus of the National Curriculum and its associated national testing it was not surprising to find this response.

Most of the pupils enjoyed practical work, felt they were good at it and that it was easy. In Year 7 school science in a laboratory is a new and exciting experience for most pupils; HMI (1987) reported that in the early secondary school years pupils enjoy working in specialist rooms and being involved with practical work. *Many pupils did not like the writing associated with school science.* More than half of the girls and one third of the boys felt that school practical work could have been more interesting. This data suggested that pupils had a preference for being active and doing fun and interesting experiments, rather than being passive and completing hard and sometimes boring writing activities. In their research findings Piburn and Baker (1993) stated that pupils preferred activities to bookwork and preferred open-ended lessons rather than teacher prescribed lessons. Some pupils would have liked more time to discuss their work to deepen their understanding and others would have liked increased levels of autonomy either in practical sessions or doing IT work. The suggestion that pupils would like to go on more trips and watch more videos could be interpreted as them wanting to observe practical applications of science in the 'real' world.

In Year 7 35 per cent of boys and only two girls (5%) responded that they were 'extremely good at' or 'very good at' science. By Year 8 85% of boys and 55% of girls responded that they were 'extremely good at' or 'very good at' science. This was similar to the questionnaire data and was supported by other research (Johnston, 1997) that found boys consistently rated their abilities more highly than girls. *In Year 7 and 8 more boys than girls felt that school science was important to them.*

The Year 7 data suggested that girls were less confident in their abilities to do school science compared with boys. A significant positive change for boys and more for girls in Year 8 possibly

reflected pupils' increased confidence and familiarity with ways of working in a laboratory. That some girls were lacking in confidence compared with boys was supported in a range of earlier research studies by Dweck, Davidson, Nelson and Enna (1978) and the Assessment of Performance Unit (APU) surveys (DES, 1988a, 1989a and b). Licht and Dweck (1987) argued that boys were more confident about their abilities to achieve in challenging intellectual tasks, even though this confidence may have been misplaced. In contrast girls were generally more tentative.

A few girls and boys considered that boys and girls were equally able to do school science. But, there were many comments indicating that fairly common stereotypes still existed within the research cohort. Some boys were perceived as reluctant writers, better at experiments particularly involving electricity and mechanics, enjoyed messing around and doing experiments, showed off to their friends and were immature. Girls were described as being more mature and better at written work and bookwork, generally more compliant and more reluctant to do practical work. This latter position was supported by Kelly (1987):

Girls' timidity may mean that they take less part in classroom discussions and avoid experiments that they consider dangerous. (p.134.)

Clarricoates (1987) reported issues affecting girls' and boys' different perceptions of their school science. She suggested that boys took up most space in the classroom, dominated teacher time because of their behaviour, were usually first to get their equipment and on the occasions they were not first, obtained their equipment from the girls.

More girls than boys made a number of comments in both years suggesting that girls were more mature in their approach and were more conscientious than boys. A major study (Keele University 1993 -1994) surveyed attitudes of 7000 secondary school pupils. Some interim results (Johnston, 1997) demonstrated that girls were less disaffected by school in comparison with boys, particularly in relation to their motivation for learning. The girls more than boys interviewed in my research seemed more willing to work regardless of their interest in the subject. Bleach (1998) reported that girls often displayed compliance as a part of their gender-stereotyped role and often boys adopted

behaviours that fitted them into the dominant macho stereotype. He argued that sometimes it would be difficult for pupils to go outside these accepted roles and challenge them and for many pupils it would be easier and less frightening to remain within the accepted gender stereotype. As always there were exceptions to these stereotypes and a few pupils commented that not all boys were immature and some girls were interested in science. It is important to note that nobody is quite like the stereotype as it is a constructed image to which 'real' people can only ever approximate.

Girls more than boys articulated problems with teacher explanations being too complex and commented about how their relationships with teachers could be improved. Only girls mentioned that their teachers should be more enthusiastic, should provide more supportive feedback and respect them, and their views, as individuals. Girls' feedback corresponded to Watts, Bentley and Hornsby's (1993) view that the teaching and learning situation should provide support for pupils to reconstruct their ideas through experimentation, discussion and reflection and this process requires an emotional investment. If girls felt uncomfortable with their teachers it would be increasingly difficult for them to admit they had not thoroughly understood something. At this age too the problem would be exacerbated because of the increasing importance of the peer group.

Maybe some of these difficulties could be related to the notion of 'connected' knowledge (Staberg, 1994); that is girls are more likely to want to make links between what they had already learned and what they were presently learning. Alternatively it could have been because girls were more willing than boys to admit their lack of understanding associated with school science. Black and William (1998) stated that:

...the dialogue between pupils and a teacher should be thoughtful, reflective, focused to evoke and explore understanding, and conducted so that all pupils have an opportunity to think and express their ideas. (p.12.)

Responses during interview indicated that this was not the case, more particularly for girls than boys. Only two boys discussed teacher effects on their learning and this was associated with wanting their teachers to make them work harder. Although some girls and boys stated that school

science was rushed, only girls mentioned that the time factor had an effect on their understanding of school science.

Woolnough (1991) reported that good, lively teaching with plenty of feedback and opportunities for interactive groupwork and open ended practical work would encourage higher levels of interest. My data supports Woolnough's findings, as specifically some Year 8 girls felt intimidated by their teachers in science and would have liked their teachers to treat them more as equals. These negative teacher effects could lead to later avoidance of science. Teachers need to be aware of differences between girls and boys that existed before they enter school in order not to reinforce these.

Key points from the interview results

- The majority of pupils did not perceive that school science was a gendered subject.
- Many pupil comments indicated stereotypical views about girls and boys, with girls being seen as more mature, compliant and better at written work than boys and boys being seen as less mature, more boisterous and better at some topics in school science than girls.
- Pupils preferred being active in school science.
- Pupils felt that school science was important to them.
- Girls were more concerned than boys about the affective environment (teacher relationships, explanations, personal understanding and classroom atmosphere).
- There were some gender differentiated responses emerging but there was some overlap in the responses of girls and boys suggesting that perceptions from gender groups should not be viewed in isolation from individual views.

There were very few differences in the responses of the girls' only schoolgirls and the co-educational schoolgirls. The only exception was in response to the questionnaire in Year 8 where co-educational girls were more likely to say that they were good at or liked some aspects of school

science more than girls' only pupils. Therefore I intend to continue to group all of the girls together for the purposes of analysis in the Year 9 research.

Chapter 5 Pupils' views and feelings about science in Year 9

5.1 Introduction

My theoretical perspective argued in Chapter 2 and 3 gives priority to the use of qualitative methods to continue to investigate the relationship between gender and pupils' evolving disposition to science. I decided to continue with a qualitative approach only i.e. interviews. The evidence from the data collected in Years 7 and 8 (and discussed in Chapter 4) indicated that interviews rather than questionnaires provided richer and more nuanced insights into pupils' perceptions and gave their voice more significance. The interview schedule used for the Year 9 cohort (see appendix 9) contained some additional questions to that used for Year 7 and 8 about pupils' future study, vocational choices, subject preferences (physics, chemistry and biology) as well as whether, given the option, they would continue to study all three sciences at GCSE level. For the Year 9 sample the same approach to the analysis was used and the interviews were fully transcribed. I continued to group the girls' only and co-educational girls together based on findings in Chapter 4 that there were very few differences between these groups. I was aware that I needed to notice any differences developing between these girls' groups (see p. 124).

At this point I began to identify individual pupils' responses to enable me to track changes over time as the research continues. As the pupils were older, I expected they would be able to more clearly articulate the reasons for holding particular attitudes towards their school science experiences. During interview analysis I necessarily selected pupils' comments to enable me to represent the wide range of pupil views, the comments presented in this Chapter therefore were not all from the same individual. I decided not to include all of the idiosyncratic comments. In this Chapter I compare Year 9 responses with those given in Year 7 and 8 to demonstrate how some pupils' dispositions were shifting through Key Stage 3.

5.2 Sample

The interview sample was planned to consist of 60 Year 9 pupils (40 girls, 20 boys) from three schools, previously interviewed in their Year 7 and 8. The actual number of pupils able to participate in interview was smaller than the selected sample because of school absence on the day of interview. The final sample was 35 girls and 18 boys.

5.3 Pupils' perceptions about science

The majority of pupils (80% of boys; 97% of girls) thought that girls and boys were equally good at science in school. *Most pupils (83% of boys; 91% of girls) thought that school science was aimed equally at girls and boys.* Similar responses were given in Year 7 and 8. Comments made during interview reflected similar gender stereotyping to that found in Year 7 and 8 interviews.

More than half of the pupils (54% of girls and 55% of boys) reported that they were 'OK', 'good at' or 'extremely good at' school science. Girls were therefore equally confident in their abilities to do school science as boys at this age. *However, in comparison with Year 8 data the percentages responding in these categories were much lower.* Both boys' and girls' views of their ability in science increased from Year 7 to Year 8, although boys started out with more positive views of their ability than girls. By Year 9 both boys' and girls' views indicated that nearly half of the pupils no longer considered themselves competent at science.

There was much agreement among pupils about what they found exciting and enjoyable about school science with practical work again being rated the most popular activity for 25/35 girls and 12/18 boys. The majority of pupils interviewed thought they were good at practical work: 28/35 girls, 14/18 boys. Pupils enjoyed the active, personal involvement with group practical work. *A number of pupils mentioned that they learned more in these situations compared with more passive activities, for example, watching demonstrations and completing written work.* They said this was because they could discuss their work with friends and this increased their enjoyment and understanding in science.

The majority of pupils: 28/35 girls and 15/18 boys found the writing activities associated with school science very boring. Particular writing activities mentioned included: copying from the board, bookwork and completing worksheets. 24/35 girls and 11/18 boys found writing activities easy in science, with smaller numbers, 5/35 girls and 4/18 boys finding practical work easy. However in Year 9 pupils reported an increase in the number of 'boring' writing activities in science and felt that although generally these activities were easy they were not as enjoyable as more practical activities. Pupils' preferences for practical activities reflected their views in Years 7 and 8. Table 5.1 shows boys and girls responses to how important school science was to them across three years.

Table 5.1 Years 7, 8 and 9 percentage pupil response to the question: Is school science important to you?

Response	Year 7 girls	Year 7 boys	Year 8 girls	Year 8 boys	Year 9 girls	Year 9 boys
Yes	83	100	83	100	46	84
No	17	0	10	0	43	5
Don't know	0	0	7	0	20	11

Over the three years boys responded more positively than girls that school science was important to them. Boys' responses became slightly more negative in Year 9, but girls' responses to this question became much more negative by Year 9 with nearly one half of girls stating that science wasn't important to them compared with only one boy. There was a skew between girls in different schools: with more girls (53%) in the girls' only school stating that science was not important to them compared with girls in the co-educational school (33%). Also it was notable that the girls' only school responses had decreased to only 24% of girls stating that science was important to them, compared with 67% of girls from the co-educational school.

Girls and boys gave similar responses about why science was important. Apart from a small number of girls, all pupils felt science was important (about one-third in each category-work, life

and both work and life). Some reasons given for why school science was perceived as important to pupils were:

Science teaches you about life. If we didn't learn about science we would be like cavemen because it tells us about everything, it even tells us right from wrong. Useful for surgeons and computer work. (girl)

...Don't know why I learn science, I suppose it's in everything you do...gravity, there's a lot of common sense as well... don't think of science as important but I suppose it is.(girl)

You learn science for life, to plug things in, want to understand how things ...work, for everyday it is important. Yes it is important to me for jobs. (boy)

Important, not just for jobs...if you work with chemicals you won't blow things up... (boy)

So you know what's going on, how things happen in the universe and the world. (boy)

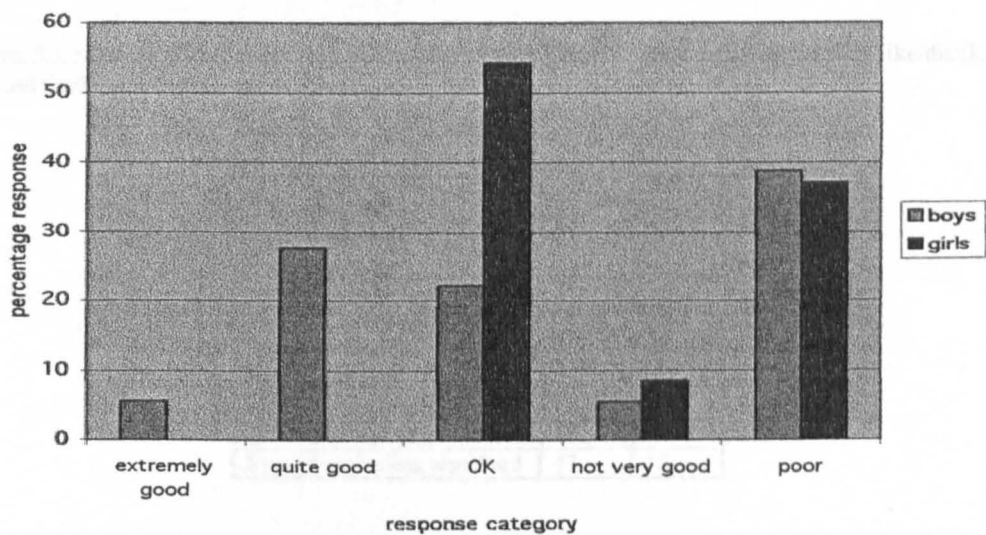
It will be when you're older for jobs and health information. (boy)

Many pupils, 7/18 boys and 16/35 girls, would have liked more practical work and finding out more for themselves 8/18 boys and 19/35 girls. Smaller numbers of pupils suggested that they would have liked to do more enjoyable practical work. 9/35 girls and 5/18 of boys would have liked less written work including copying from the board and from books. All of the improvements recommended were in common with those suggested in Year 7 and 8. These findings reinforce what pupils said about what they enjoyed about school science. They wanted to be even more actively involved and generally wanted to find more out for themselves. A number of pupils said that practical work and observing scientific things in the 'real' world supported their learning. Having opportunities to share results was important to pupils, as this conferred value to their findings as well as helping them to develop their understanding as they explained their results and the meanings associated with them. As in Year 7 and 8 very few pupils in Year 9 (1 girl, 2 boys) thought that boys were better at science than girls. Very few pupils in Year 7 (4 girls, 3 boys) and

Year 8 (4 girls, 0 boys) thought that girls were better at science than boys and no pupils thought this in Year 9.

When asked how good they were at school science boys responded more positively than girls. In Year 9 there were marked differences in the responses of boys and girls. The data is presented in Figure 5.1.

Figure 5.1. Year 9 pupil percentage response rate Year 9 to the question; Are you good at science?



In Year 9 about one third of boys and no girls responded they were 'extremely good at' or 'quite good at' school science. The majority of girls (54%) compared with only 22% of boys responded in the 'OK at' science category. Even though the overwhelming majority of pupils did not believe that gender and ability in school science were related boys still responded more positively about their ability than girls. By Year 9 nearly one half of all pupils (46% of girls, 44% of boys) responded they were 'poor at' and 'not very good at' school science.

More boys than girls said they found science exciting in Years 7, 8 and 9. In Years 7 and 8 over three quarters of the boys and two thirds of the girls said they found science exciting. By Year 9

this had fallen to below half of the boys and about a third of the girls. More girls (7) than boys (1) suggested that school science was an interesting rather than exciting subject. Five girls and one boy were bored with all of their school science studies.

Pupils were asked whether they liked particular disciplines within school science in Year 9. Their views were expressed in terms of how they experienced the subjects. In table 5.2 the number of different types of responses (selected as good, commonly occurring examples) are recorded as percentages.

Table 5.2 Number of responses as a percentage to the question: 'what subjects did they like/dislike or find hard in the Year 9 curriculum?'

Area of curriculum	Boys	Girls
Physics was boring	7	29
Chemistry was hard	47	44
Physics was hard	20	24
Biology was hard	13	6
Biology was interesting	0	56
Physics formulae were hard	13	3
Forces were hard	0	15
Energy was hard	0	6
Electromagnetism was hard	0	9
Electricity was hard	7	18
Symbols/equations were hard	47	12

The results reflect some of the survey findings for example more girls' comments than boys are about physics being boring and many girls' comments are about biology being interesting whereas no boys make this comment. Two boys and two girls rated physics, chemistry and biology at the same level of difficulty. Many girls suggested that they found biology interesting because it was more relevant to them than physical science subjects. Those pupils who thought biology was hard did so because of particular topics: pupils mentioned genetics, ecology, naming human body parts and blood as difficult topics. Two boys stated:

I don't like biology as much as physics and chemistry...you can't see what's happening, whereas you can in chemistry. I'm not too interested in remembering the parts of the body.

Find biology the hardest because it's the least interesting, bored...don't try therefore, it is more difficult.

More girls than boys found physics overall, and particular physics topics, hard. Some reasons given by girls for this were:

My physics test results are good, but I don't understand wires and energy, why do we need to know about them? Electromagnets are nothing to do with life therefore I don't want to learn about it, it becomes hard.

We cover too much physics in the lessons, it's hard to learn because of that - not interested in science...don't want to know anyway...physics is really boring...no use unless you want a sciency job.

Forces and electricity are hard in science, tried to understand, maybe hard because of the maths, I'm not confident in maths therefore physics is hard.

How to close a door with a Newtonmeter is not my idea of a practical...not fun, not interesting, don't learn.

From boys:

Physics is hard in science...the idea of mass is hard.

Physics is not very active or exciting this year.

Find circuits hard because I least enjoy doing them.

A number of pupils (more girls than boys) found chemistry hard particularly the introduction of symbols, equations and the periodic table. Some reasons given for this were:

Everything apart from equations is accessible. (girl)

Equations are not exactly useful for jobs! If you have got to learn it you may as well make it interesting. (girl)

I don't think physics is hard, chemistry is hard because of all the formulae. (boy)

Many pupils enjoyed chemistry even though they found some of it hard, particularly formulae and equations. Maybe this dichotomy in response from some pupils could be explained because many chemistry lessons were practical and they enjoyed these, even though they found the theoretical content difficult. One girl responded that:

It's difficult to compare...[how difficult subjects are because] it depends whether you enjoy them.

Girls (10) more than boys (2) responded that school science could be improved if it was more relevant to them. Eight girls also mentioned that science would be better if there was more IT, more depth, selective writing up rather than whole experiment, more active work and more discussion during planning. Four boys commented on how to improve their school science lessons with more practice on past exam papers, more practice on balancing equations and more work with dead animals.

13/35 girls wished to drop some or all of science compared with only 3/18 boys. This illustrates a gender disparity with respect to continuation of study in school science. Three girls wanted to drop physics and chemistry, one girl wanted to drop physics, two girls wanted to drop chemistry, one girl wanted to drop chemistry and biology, one girl wanted to drop biology and five girls wanted to drop all science. One boy wanted to drop biology and two boys wanted to drop all science. There was no response from two girls to the question; twenty girls and all of the other boys did not wish to drop science. Some girls' reasons for dropping all science were that it was boring, irrelevant and repetitive. Typical girls' comments included:

Drop physics definitely and possibly chemistry if it wasn't necessary for a job.

Not interesting enough...it's just repeating.

Do not enjoy science....dread every lesson because it is just boring.

Yes, because it is not relevant to my future.

Four girls stated that they would not drop science as they felt that it was important for them to be able to get a good job. Other girls commented that they would continue because:

No, because I am struggling and would like to achieve.

No, but I'd reduce the number of lessons.

No, because I like it.

More girls than boys would opt out of all or some aspects of their school science studies given the option.

Some pupils perceived that girls and boys were better at different aspects of their school science experiences. Many pupils (both boys and girls) saw girls as better organised, more mature, and more concerned about pleasing their teacher, better at revising and better at English rather than science.

These days girls are more in control than boys who are just at the back of the class, boys are going down. They seem to be very immature by the day and they don't let the girls work. It's mostly boys that cause the trouble...(girl)

Boys mess around more, girls tend not to mess around as much, the girls are more mature. (boy)

Usually the boys shout out and the girls don't get a chance. Boys are more interested in the subjects; girls are less interested in science than boys. In maths boys do better in tests, in English girls do better, boys do better in science. (girl)

Some girls are boring - goody goody, sucking up to the teachers, they are not fun. (boy)

Some pupil comments selected for quotation here provide evidence about the essence of the discussions held:

Don't think it matters it's you as a person, it doesn't matter what gender.(girl)

Most girls and boys want to learn. (girl)

Doesn't matter [whether you are a boy or girl] we are all the same. (boy)

Sometimes boys mess around more, sometimes girls.(boy)

Other pupils (both boys and girls) suggested that some girls did not understand science, did not listen or even like science. Some pupils suggested that girls were shy, quiet and wary about some experiments.

Some girls will say "eerrr that's horrid" [when doing experiments with maggots], girls are more squeamish, boys do things without thinking. (girl)

Girls don't like to touch hot things like the Bunsen burner and test tubes. (boy)

Some comments made by pupils about boys were that: they messed around more, were better at science and maths and achieved better marks in science tests than girls. Some pupils (both boys and girls) said that science was aimed at boys, that boys were more interested in science.

Some girls are chatty, therefore they don't listen and don't understand. In our class the girls are more shy than the boys. Boys do better in science tests. Girls are more organised and do more revision. (boy)

Maths and science boys do better because they are more interested in technology, transport, planes and cars. Girls don't understand science as well as boys so they don't do so well in tests, maybe because they are not so interested in it. (boy)

Most of the girls in my group don't like science, most of the boys do because they are interested, they don't understand it better, boys revise more. A lot of them mess around and are immature, they throw rubbers and flick elastic bands, I don't think they're cleverer. (girl)

Some pupils mentioned gender stereotyping on TV and others suggested that all of the great scientists were male and that science would lead to 'male' jobs. Some typical pupil comments:

Men get more jobs to do with science, e.g. engineer. Girls chat more. (girl)

Science is aimed more at boys, look at the great scientists, there are not that many women, because you have to cut up animals, girls don't want to touch, shows you that on Grange Hill. Lots of women are 'veggie' they don't want to cut animals up. (boy)

Cutting animals up is not in their [girls'] nature. (boy)

Depends what subject you are studying, biology is for girls. (girl)

In the olden days, girls weren't allowed to do science. (girl)

Although the great majority of pupils did not state that science was a gendered subject in their comments some pupils indicated how science was 'masculine'.

Inevitably during the interviews pupils discussed issues concerning their school science experience that had not been directly asked about. If pupils responded about particular topics more than a very few times I collated their comments and these are considered below.

Pupils' views of teachers

Although pupils were not directly asked about teacher effects on their school science experiences, many pupil responses to questions like 'how would school science be better' included references to teachers.

Pupils were asked to state how good they thought they were at science and they were also asked to indicate whether their teacher supported their judgement. 12 girls and 17 boys thought their teacher supported their judgement on their ability in school science. More boys more than girls perceived they were good at science. The following responses were given where there was a perceived disparity in teacher and pupil judgement of ability. One boy and four girls suggested their teacher thought they were good at science and they thought they were OK at science. Seven other girls also thought they were not good at science but believed their teacher thought they were OK at science. 12 girls did not know what their teachers thought about their ability, seven thought they were OK at science and five thought they were not good at science. Two girls thought they were good at science and they thought that their teacher thought they were not very good. More girls than boys seemed to be unsure of what their teachers' views were on how good they were at science. Some girls were more hesitant than boys about how good they were in science. One girl commented:

Miss suggested triple science¹ next year, but I'm not sure I'll keep up with all of the writing.

¹ Three separate subjects of study.

Year 9 girls made many negative comments about their teachers and would have liked more teacher time and teacher praise, better teacher explanations, better teacher control. and less teacher talk. Like a number of the girls, two boys would have liked better teacher explanations.

Many individual comments made by girls were about the relationship with their teacher. They wanted teachers to listen more and to be more relaxed. They wanted greater involvement from the teacher and more respect and more enthusiasm from them. Other girls' commented:

Yesterday I put my hand up to ask a question and the teacher said X has got an intelligent question to ask...bit of a 'show up' I'm not exactly a brain box.

I would like less teacher talking and for the teacher to take more interest in us...would like the lessons to be more interactive.

Teacher having a laugh rather than being just boring.

If the teacher got more involved, not just with the science but with the pupils, teaching us as friends rather than pupils, it would develop respect.

Too embarrassed to talk to the teacher, we need to feel more relaxed.

Some teachers make you feel as though you can't ask, it's the same in maths.

Boys rarely commented on their relationships with teachers during interview, only that they could have been stricter.

More girls than boys were concerned with a variety of factors related to the teacher-pupil relationships. This may be associated with how pupils feel in science classrooms, with girls being less confident and more concerned about how others (peers and teachers) responded to them. Girls mentioned being embarrassed by their teachers and therefore not feeling comfortable enough to ask questions in order to further their understanding. These findings are similar to those in Year 7 and 8 but there were fewer comments in Year 9 about understanding teacher explanations.

Pupils' views on time

Several pupils, more girls (9) than boys (2), complained about the lack of time to complete practical work, to repeat experiments and to carry out real investigations. Some pupils wanted more time to cover difficult topics and to not swap from topic to topic frequently. Two girls' commented:

This year it's too rushed and the teacher expects you to know it all. The teachers are rushed too.

There's no time for us to ask questions after the teacher has finished talking.

Some boys suggested that they would like to have had more time for writing up their experiments, for comparing notes and for discussion. Whereas girls often wanted to have more time to ask questions, for more detailed explanations, more time for planning and generally more time so that they would not always feel that they were in a rush. Some pupils (girls and boys) felt did not have a problem with time in science lessons. Problems with lack of time in science lessons were also found in Year 7 and 8.

Pupils' post 16 study ambitions

Pupils interviewed were asked as an exploration of their thinking at this stage of their schooling what they would choose to study post 16. Their responses were wide ranging with 7 boys and 21 girls considering studying A levels and 10 girls and 5 boys considering studying GNVQ at school. There was some evidence of gender influencing choices at A level with only girls (9) and no boys planning to study humanities (geography, history and religious education) subjects. There were also choices that follow recent trends in studying 'mixed' A-level subjects (5 boys and 9 girls). Very few pupils planned to study only science courses (2 boys and 3 girls). Of the pupils thinking about GNVQ study, the subject choices for girls were: science related, dance, Social and Health Care, hairdressing and childcare and for boys: graphics. A few boys and girls considered studying sport and leisure and art.

More girls planned careers in writing, teaching, social work than boys and more boys planned careers in graphics, working with electricity, accountancy or to become a 'businessman'. One girl *intended to be a pilot with NASA and another wanted to be a bank manager.*

5.4 Discussion

The Year 9 research findings illustrate similarities and differences in boys' and girls' dispositions towards their school science learning experiences during Key Stage 3. This research suggests that over the first three years of secondary schooling, girls' and boys' attitudes towards their school science experience become more negative. Obviously it must be borne in mind that the sample was taken from only three secondary schools in Coventry, England. However great care was taken in the selection of pupils for interview to make the sample as representative of the general school population as possible.

Factors that affected pupils' dispositions towards their school science learning experiences were broad ranging and included perceptions of self-efficacy in school science, subject preferences within school science and pupils' views of the importance and the relevance of school science to themselves. Other factors that affected pupils' dispositions were difficulties they experienced associated with some aspects of school science, for example conceptual difficulties with chemical equations, approximately fifty per cent of all pupils interviewed said they experienced these difficulties. Many pupils were concerned about other features that limited their engagement and their learning (too much content and too little time) both of which were indirectly imposed by the introduction of the National Curriculum (NC) in 1989.

The great majority of pupils interviewed over Years 7, 8 and 9 did not perceive that school science was aimed at either boys or girls, or that boys or girls were better at science. However it seemed that pupils' views of school science did not correspond closely with their views of science outside of school. Some pupils suggested that all famous scientists were male, that science was aimed more at boys than girls and that boys were more likely than girls to enter scientific professions.

Weinrich-Haste (1981) found that school science often reflected the cultural stereotype of masculinity. This finding was supported by comments expressed during interview by some Year 9 pupils. *One reason pupils suggested that the male image of science and scientists continued was because most scientists were perceived to be male; an image that they felt was reinforced by stereotyped images portrayed by peers, adults and the media.* Flam (1991) argued that the situation existed where many laboratories, journals and professional institutions had a masculine atmosphere; this view was supported by Gipps (1996). Gaskell and Hildebrand (1996) draw *attention to the tensions some girls experience between 'Being a good student and a feminine young woman'.* (p. 41.)

During Key Stage 3 there was a reduction in many pupils' reported level of confidence in school science that may well have had an effect on pupil interest in science as a school subject. By Year 9 pupils perceived that school science had become less important to them than it had been in Year 7 and 8, particularly for girls.

There were many common responses from girls and boys about how their school science experiences could have been made better. Pupils in all years would like to have completed more interesting and relevant practical work, more group work, to have more time particularly for discussion, and to have less writing and copying to do. Some Year 9 pupils would have liked more independence in their learning and better teacher explanations. Implicit in pupil comments was an understanding of the importance for their learning of their personal involvement with, and personal responses to, their school science experiences. Keys and Fernandes (1993) supported this finding and reported in all subjects that Year 7 and 9 pupils expressed greatest preference for lessons where they could work with their friends, their second choice was a preference for lessons where they could make things and their third choice was lessons in which they had discussions.

The notion that teaching and learning practices should be active rather than passive has been argued by leading educational theorists and others whose theories have had a major influence on

education such as Dewey (1929), Piaget (1953), Vygotsky (1962) and Bruner (1989). Watts, Bentley and Hornsby (1993) theorizing about science learning in particular also discussed the importance of *learners being active in the learning process and suggested that this activity involved speculation, experimentation and re-formulation of pupils' own ideas*. For pupils to be effective learners they should be enabled to actively construct and re-construct their personal understanding within their school science lessons. Watts, Bentley and Hornsby (1993) also believed that these 'making sense' activities required an emotional investment.

Watts, Bentley and Hornsby (1993) provided a seven-point description encompassing the key factors for active learning within a constructivist framework. They suggested that pupils should be allowed to be more autonomous in their learning and pupils should want to develop knowledge of the subject or find solutions to problems as well as taking responsibility for their own learning. *It would be important that the work was relevant, had a clear purpose and be related to everyday contexts*. Watts et al. (1993) stated that pupils need to develop the skills required to transfer their learning across contexts but this would only occur when the pupils had feelings of ownership over their data, their interpretations and understanding. Pupils need to manage their own time, make decisions about what work needs to be approached individually and also be aware when a more collaborative approach would be beneficial. *They would need to share their understanding and knowledge in a variety of ways, for example through discussion, presentations, posters, etc*. They also argued that if pupils were active and effective learners they would have identified ways of *assessing their own and others' progress*. When sharing their self evaluations or peer evaluations pupils needed to be supported in a non threatening learning environment, so that they could feel confident in being prepared to review and defend their thoughts. Lastly, as a result of effective learning Watts et al. (1993) argued pupils should be encouraged to believe in themselves and this would lead to them becoming more enthusiastic about their learning activities. Through these positive learning experiences pupils would develop an awareness that learning was emotional, exciting, required persistence and could sometimes be disappointing. If learners were personally

engaged with the learning process they would be more likely to be successful, would be more confident and most likely would be more motivated to pursue their study of the subject.

My research findings do suggest that many pupils had become demotivated with their school science by Year 9. Even with the introduction of the National Curriculum (1989) that makes science compulsory to all pupils from 5 - 16 years old, there were still a number of pupils (more girls than boys) in my sample who would have liked to opt out of all science or at least some subjects at 14+. *This was a serious matter of concern as Fensham (1993) stated:*

If a learner loses motivation or fails for whatever reason to learn one stage, then it is almost impossible to recover. (p. 113.)

However, when asked if they were given the option to finish their study of science, the majority of pupils (66% girls compared with 83% boys) did plan to continue with their science studies at Key Stage 4.

Some of the key differences between girls' and boys' views on their school science learning experiences during Key Stage 3 were that more boys than girls said they were good at science, liked practical work more, messed around more and showed off more. These findings were evident in the comments expressed during interview by Year 9 pupils. Boys more than girls found that school science was exciting in Years 7, 8 and 9; but the number of boys and girls commenting about how exciting school science was had fallen by Year 9.

By Year 9, more girls than boys in my sample had less positive views of their school science learning experiences. Many Year 9 girls suggested that science was no longer interesting and they felt that much of what they learned in science was irrelevant to them. Girls also referred more frequently than boys to their concerns about their personal understanding of subject matter. When pupils were asked whether they were good at science, there were noticeable differences in the responses of girls and boys. More boys than girls stated that that they were good at science in school. Over half of the girls interviewed rated themselves not very good at science in Year 7, all

pupils responded much more positively in Year 8. But this changed in Year 9 with both girls and boys responding less positively (more than one third of all pupils responded in the 'poor at science category'). *Steinkampf and Maehr (1983) cited research that indicated:*

Females are less likely to attribute success to high ability and more likely to attribute failure to poor ability than males. (p.201.)

Baumert (1995) reported that interest was strongly correlated with self-perception of ability (what individuals think they are good at) rather than actual performance. She found that girls' perceived competence in stereotypically male subjects were lower than boys and this reflects the operation of negative stereotypes about females in subjects like science and maths. These negative stereotypes can be counteracted by teachers establishing links between the information to be learned and pupil's self-concept or identity, by having high expectations for all pupils, and by interacting positively towards individual pupils. Pupils were asked whether their teacher supported their judgement of how good they felt that they were in science. In Year 9 more girls than boys were unsure about what their teachers thought about their ability in science, whereas boys generally appeared to be more knowledgeable and confident in what they and their teachers thought about their ability.

Questionnaire responses indicated that pupils did not hold particular gender stereotypes, but further exploration during interviews in Years 7, 8 and 9 gave clear indications of the existence of gender stereotyping. Watts and Bentley (1993) argued that active learning approaches could enable girls to draw on their particular experiences to help them provide ideas and solutions to scientific problems. They argued that simply supporting girls in the science laboratory and developing their confidence as learners was not the answer to the girls' and science problem. They argued, like Kelly (1987), that existing school science frameworks needed to change. Murphy (1989) suggested that factors occurring in the classroom have major effects on the personal knowledge and self-image of pupils, particularly with respect to race, gender and class. Teachers can act as powerful agents by reinforcing gender stereotypes within schools in terms of their behaviour, expectations,

interactions and pedagogical style. Alloway (1995) criticises teachers who fail to intervene arguing that:

Inaction by professional educators can be read as implicit endorsement of inequalities in gender relations. (p.61.)

Through Years 7, 8 and 9 boys responded more positively than girls that they felt school science was important to them. Pupils' perceptions of the importance of school science to them were very similar in Years 7 and Year 8 with more boys than girls saying that science was important to them. *This difference between girls and boys increased in Year 9 with one third of the girls stating that science was not important to them.*

When pupils were asked what they liked or disliked about school science many more girls than boys mentioned teacher effects. Girls discussed the importance of liking the teacher and their concerns about the quality of teacher feedback, praise and support. Only one boy mentioned the need for teacher feedback in his book to be more positive. Driver et al. (1984) suggested that any learning outcomes in school science depended not only on the learners' conceptions, but also on their personal motivation as well as on the learning environment, which is where pupils' social interaction with peers and teachers takes place. Halyadna et al. (1982, 1983) discussed the importance of the learning environment being supportive of pupil learning and being key to the development of positive cognitive and affective attitudes. Watts and Bentley (1989) elaborated aspects of these theoretical views on the cognitive and affective environment:

...the very act of learning is an emotional affair. The cognitive and affective are not separate and distinct but are irrevocably intertwined. (p.161.)

Some girls suggested that they found discussing misconceptions with the teacher and understanding teacher explanations very hard. Gilbert and McComish (1990) discussed the importance of ensuring that all pupils participated in lessons and that everyone's experience was listened to and valued. Other girls mentioned that they expected teachers to respect them more and to have more enthusiasm for their subject. The interview data indicated that teacher effects

sometimes exacerbated the problem that some girls felt 'out of place' in their school science laboratories. The boys interviewed generally did not mention teacher effects on their learning.

Bentley and Watts (1986) cited evidence illustrating that some girls surveyed had asked for the nature of the learning environment to be changed to one:

...in which trust of girls and their ability to develop their ideas, theories and solutions is of paramount importance. Where the value placed on their ideas is not automatically secondary to that placed upon the teacher or boys in the class. Where they will no longer have visited upon them that they will sit quietly, undisturbing, simply following instructions acquiescently. (p.130.)

Some of the reasons suggested for pupils' lack of interest in science in school were associated with pedagogical style. Many girls, and some boys, in my sample did not feel that there was a 'shared partnership' in their science lessons and this may have been a part of the reason that many of the pupils' levels of interest in science dropped considerably by Year 9. The science teaching and learning process was perceived by many pupils as being tedious and restrictive, with didactic teaching methods and too much teacher talk with inadequate explanations, many demonstrations, much learning of facts, repetition and copying of work. Schibeci (1984), Whyte (1986) and Head (1985) explored how attitudes were influenced by the teaching context. Driver et al. (1996) reported that the science curriculum was still perceived by some teachers as a body of knowledge to be transmitted. Extensive studies in science classrooms have shown teachers too often representing science as a body of facts with a set of empirical processes. Girls more than boys were concerned that there should be a context for learning school science and sufficient time allowed for them to engage more effectively with their school science learning experiences. The ASE (1979) had earlier stated that science was becoming too pure, conceptually demanding and complex and therefore had become a subject with little meaning, relevance or interest to many learners. Hendley et al. (1995) found in their research at Key Stage 3:

A factor that emerged clearly as a negative influence on attitude was the growing abstraction and complexity of science classes. While this applies to both boys and girls, it was found to be more marked in the case of girls. (p.87.)

Claxton (1997) and Aikenhead and Solomon (1994) argued that areas of contemporary relevance rather than traditional laws and theories would make science less alienating to all pupils.

Woolnough (1994) commented that:

Science in schools is often criticised, especially by older students, for being too prescribed, too impersonal, too lacking in opportunity for personal judgement and creativity. Science has become reduced to a series of small, apparently trivial activities and pieces of knowledge unrelated to the world in which the students are growing up and inhibiting their developing personalities and aspirations. (p.9.)

Other research (Fensham, 1993; Mahony, 1998) reported that more relevant and contextualised approaches to school science were particularly important for girls. Sjøberg and Imsen (1991) found evidence to show that the science curriculum should have:

An organisation based on personal relevance is important, especially for girls; for example, the physical senses and the human body, the use of science to improve life for ourselves and other people. (p.245.)

The opportunity to share opinions, thoughts and feelings about various aspects of school science might have been avoided by science teachers partly due to restrictions on curriculum time with too much content to cover and partly because of the traditional ways perceived to be associated with the teaching of science.

The School Science Curriculum Review (SSCR, 1983) argued that all pupils should study aspects of science that were essential to an understanding of the self and their personal well being and to be given the opportunity to discuss, reflect upon and evaluate their own personal understanding of key science concepts, theories and generalisations. My research findings indicate, particularly for Year 9 girls, that, despite the introduction of the National Curriculum they still (almost 20 years later than research quoted here) were not provided with sufficient time to reflect, discuss and evaluate their understanding. Also, even though some of the content of the science curriculum changed with the introduction of the NC, pupils, particularly girls perceived that the 'new' content still lacked relevance to them.

The number of comments about the lack of relevance of school science increased particularly for girls during Key Stage 3. For example a Year 9 girl stated that they should study 'topics that matter'; other Year 9 girls stated that *electromagnetism, mixing chemicals, equations and electronics* were not relevant to their lives.

Many of the Year 9 girls in my sample disliked physics (almost one-third of the girls suggested that physics was boring, whereas more than half stated that biology was interesting). They found electricity, light, sound, forces and energy, particularly hard. Some of the reasons given for their dislike of these topics were associated with the relevance of subject to them; the difficulties associated with understanding it and the fact that it was often too much like maths. Many pupils (girls and boys in Year 9 and girls in Year 8) mentioned that symbols and equations were hard in chemistry. Harding (1996) suggested that familiarity with a context, or even a perception that the context may have a personal significance, would increase commitment and performance of pupils in school science. Science changes from being essentially practical and fun in Years 7 and 8 to becoming very abstract, less practical and theoretical in Year 9 and these changes have negative impact on many girls and some boys.

The relationship between pedagogy and attitude formation – a gender perspective

Versey (1990) reported that concentrating on an approach to teaching and learning that valued pupils as individuals with differing needs, interests, expectations and experiences had positive effects on girls' learning in science. She reported that attention to course material could change pupils' attitudes. This research indicated that pupils disliked and had difficulties with some aspects of science, particularly the physical sciences in Year 9. This was possibly due to the introduction of aspects of these subjects in a way that did not meet the 'interest needs' of pupils, particularly girls. Many interview responses suggested that girls often did not feel valued by their teachers and this may well have affected their interest in, and engagement with, school science. Versey (1990) argued that science teaching in classrooms should be inclusive of teacher and pupil partnership, there should be a shared 'ownership' of what went on and this ownership must be extended to all

pupils. Harlen (1993) reported that the notion of self-ownership and creativity, particularly of investigative work, positively motivated girls. In Australia, the McKlintock Collective (Gianello, 1988) addressed pedagogical reform to further meet girls' preferred learning styles with the intention of increasing the numbers of girls in science. Teachers and researchers in the Collective (during the late 1980s) studied the girls and science problem and designed innovative classroom-based intervention strategies which included gender-inclusive, relevant and student-centred curriculum materials together with innovative, active and co-operative teaching approaches. Fensham (1993) reported that the Collective's curriculum materials were consistent with a 'feminine' science curriculum and were intended to make the science content more interesting, relevant and accessible for girls and also for some boys. Hildebrand (1995) described the Collective's initiatives as gender inclusive and expansive in addition to making science and technology exciting, creative, provocative and motivating. Kenway and Modra (1992) describe the Collective's focus as:

...the development and 'dissemination' of alternative forms of non-discriminatory and empowering pedagogy, which may challenge schooling's complicity in reproducing gender inequality. (p.141.)

More girls than boys in all three years of my research mentioned shortage of time to complete their science work properly. A number of girls particularly mentioned not having sufficient time to reflect on their work, to repeat work when necessary or having enough time to discuss their own ideas and share their opinions about topics they were studying in school science lessons. Murphy (1996) argued that:

...girls more than boys prefer to co-operate and engage in dialogue with peers about their learning. (p.15.)

More girls than boys enjoyed group work as they felt they were more confident at sharing their ideas in small groups rather than at a whole class level. They felt that sharing ideas enabled them to understand more about the science topics being studied. Boys discussed the importance of group work for sharing ideas, being relaxed and having more fun, but not necessarily learning more.

Versey (1990) suggested that some pupils enjoyed the freedom of open-ended investigations whereas others preferred very structured practical sessions; some enjoyed the intellectual stimulation, others found it intellectually challenging, etc. Therefore, she argued that different teaching styles were essential to meet the needs of all children in the class. Girls more than boys in my sample did not like having the freedom associated with planning their own experiments. More boys than girls in Year 9 mentioned that they would have liked to have more independence from the teacher to develop their science learning in terms of developing their own experiments and having time to explore topics outside the National Curriculum.

Many pupils, especially girls, in my research mentioned the boring nature of teacher talk, that there was too much talk with poor explanations and consequently little lesson time left. Keys and Fernandes (1994) observed in their study that there was a dip in motivation towards schooling generally in pupils between Years 7 and 9 with substantial numbers of pupils finding their schoolwork boring. Pupils' ideas about good teaching remained remarkably consistent over the years of my research and pupils said that they did not like being 'talked at' and that they preferred active involvement in the learning process. More girls than boys complained that they were not active participants in the learning process and because of this they were becoming progressively bored with school science. Teaching strategies mentioned by pupils as being passive and tedious included copying from the board, bookwork, worksheets, long teacher explanations, demonstrations and experiments with predictable outcomes. The teaching and learning environment within school science laboratories has a major effect on the development of positive views on learning and subsequent choices to study science (Rosser, 1986). Watts and Bentley (1984, 1986 and 1987) also discussed the importance of the learning environment being non-threatening and supportive of children's learning. They argued that science environments were often places that pupils associated with objectivity and the 'cold' approach to science and this was a key factor associated with the reluctance of some girls and boys to continue their study of science. Head (1996) suggested that if pedagogy was to be gender-sensitive it should combine a supportive environment associated with praise, precise criticism and guidance. Johnston (1997)

stated that the importance of affective attitudes was generally accepted although in her research many girls' responses did not support the notion that affective attitudes were a consideration in their school science experiences. *A number of Year 9 girls in my research discussed the need for a more relaxed working environment that was supportive and enabled them to discuss ideas without feeling embarrassed. Other Year 9 girls suggested that they found science boring because of a variety of teacher behaviours, for example, poor teacher-pupil relationships and not enabling girls to have the confidence to ask questions. Affective as well as cognitive development must be considered if all pupils, particularly girls, are to respond positively towards their school science learning experiences.*

Year 9 pupils responded to a question about their future studies or work after compulsory schooling ended. Very few pupils planned to study sciences at Advanced level GCE, many pupils planned to study mixed A-levels, with only girls planning to study humanities. There were some gender stereotyped planned options in vocational subjects and in future employment choices.

5.5 Summary of findings

- Boys and girls disliked the increased levels of passive teaching/learning styles in Year 8 and more so in Year 9.
- More boys than girls thought they were good at science in all three years, but this declined for both boys and girls by Year 9.
- More boys than girls said that science was exciting in Year 7, fewer pupils said that science was exciting in Year 8 and 9.
- More boys than girls perceived school science as important, but school science had become less important for all pupils by Year 9.

Girls more than boys disliked the:

- Physical sciences.
- Abstract and irrelevant nature of much of school science.
- Poor teacher relationships.
- Quality of teacher feedback.
- Level of teacher respect.
- Lack of shared experiences in their school science.
- Lack of time for reflection and discussion of work.
- The learning environment.

These views were more evident in Year 9 than in earlier years.

6.1 Introduction

The major issues and key trends emerging from the first three years of my research have been used to inform the final stage. Although my survey data indicated more similarities than differences between girls and boys, during interview some distinctive gender differences emerged. I was increasingly aware that there were also variations within gender groups as well as between gender groups. In Chapter 5 I presented research that supported the argument for the importance of active approaches towards learning in school science. Both girls and boys became increasingly concerned that much of school science learning did not enable them to become actively engaged in the learning process and this became a major concern, particularly in physics lessons by Year 9. Throughout the Key Stage more boys than girls have a positive disposition towards science in terms of (i) their view of their competence and (ii) their view of the subject as exciting. Boys also felt that school science was more important to them than girls. Other issues that emerged as important for girls were associated with teacher relationships, teaching style, the abstract nature of much of the school science content and feeling comfortable and confident within the science learning environment.

My reflections on the evidence and data gathered during the first three years of my research and the associated development in my personal thinking led me to carry out a second literature review. The purpose of this review was to further inform my understanding of the learning process and the way in which the formation of pupils' attitudes towards learning in school science are related to learning. I also wanted to explore the influence of self-esteem¹ and self-efficacy² on the learning process from a gender perspective.

¹ A combination of agentive efficacy and self-evaluation (Bruner, 1996).

² Pupils' own judgement of their capability to organize and execute courses of action required to attain designated types of performance; dependent on the context and the learning environment.

6.2 Views on learning and knowledge

Dewey (1916) argued that research into factors affecting the learning process couldn't be carried out in isolation from a theoretical position on that process. I draw from the socio-cultural perspectives of Dewey, Vygotsky and Bruner, in developing my position on learning. The position I hold is that pupils learn by a process of personal construction and reconstruction within a mutually interactive social environment, whereby individuals participate in discussion with others as they develop their own understanding and meanings. Individual perceptions depend not only on the novel information available but also on prior educational, socio-cultural and emotional experiences.

In Dewey's statements of belief (his creeds) written during his reformist period (1897) he was passionately, and extremely confident of his vision of the nature, purpose and inevitable progress of education (Dworkin, 1959). His pedagogic creed started with his belief:

...that all education proceeds by the participation of the individual in the social consciousness of the race.

(Cited in Dworkin, 1959, p.19.)

Dewey applied his philosophical knowledge to make sense of education and his ideas developed educational thinking about the social nature of learning. He proposed that social aspects of learning included conversation and interaction with others and these together with the application of knowledge were integral to learning. He suggested that

...language... is recognised as the instrument of social co-operation and mutual participation, continuity is established ... and the origin and establishment of meanings ... (Dworkin, 1959, p xii-xiii.)

Vygotsky, a Russian psycho-linguist, had very different philosophical foundations from those of Dewey as he was concerned with the nature of evolution and transmission of human cultures. He analysed the way in which societies represented their historical development, literature, art and cultural activities and integrated these analyses with psychology. He wrote about the use of cultural 'tools' when referring to systems of representation of cultures, i.e. words, mathematical symbols, paintings and suggested that language and instruction were key to the learning process

(Wood, 1988). In the introduction to Vygotsky's translated book 'Thought and Language' (1962),

Bruner quoted an epigraph:

...it is the internalisation of overt action that makes thought, and particularly the internalisation of external dialogue that brings the powerful tool of language to bear on the stream of thought. Man, if you will, is shaped by the tools and instruments that he comes to use ... (Vygotsky, 1962, p.vii.)

Vygotsky (1962) saw social interaction as the cultural transmission of knowledge and competence. He argued that language was both social and communicative and that it had two distinct functions. Firstly language in the form of young children's monologues had a regulative and communicative function. Secondly, Vygotsky theorised that language could become a 'tool of thought' that could be used both as a system to represent the world as well as to self-regulate. He perceived that talk was a form of intellectual self-control (Wood, 1988). A number of my research sample wished to present their experimental work findings to each other as they suggested that sharing ideas and findings in this manner helped them to understand their work more clearly.

Vygotsky (op cit.) described a process whereby modes of activity that were initially assimilated in their external form were transfigured into internal processes; he called this a process of internalisation. He was convinced that this process of internalisation involved complex mental functions, which developed through social interaction.

Dewey stated that 'true' education only came from the stimulus of a child's powers by the demands of the social situation in which he found himself. He suggested that the educational process was both sociological and psychological. The psychological process incorporated the individual child's own instincts and powers, capacities, interests and habits and could not be understood unless it was translated into the child's societal equivalent; this was done by the individual being active in the educational process. Dewey (1933) argued that the act of constructing one's own understanding could be physical or mental, and that all activities needed to be mentally reflected upon, (he called this reflective activity). He saw activity as involving transactions between the individual and the environment and affecting them both. In this, Dewey considered the methods people used to

manage everyday problems. These methods enabled doubtful and uncertain situations to be turned into ones that were more predictable and certain and therefore more understandable. Dewey (1929) referred to problem solving as *'the experimental practice of knowing.'*

This conception of the mental (treating situations as problematic) brings to unity various modes of response; emotional, volitional, and intellectual.
(Dewey, 1929, p.225.)

Dewey (1929) argued further that learning should be an active process and proposed the notion of the 'active learner'. Dewey analysed educational theories in *'Democracy and Education'* (1916) and suggested that there should not be a single approach to learning. He developed a concept of educational 'experience' as a social process (he avoided the dualistic distinction of perception and objective reality). He believed in the unity of theory in practice and he described this in detail in his book *'Experience and Education'* (1938). He argued that education must be based on experience if it was to accomplish its ends for individuals and societies. Here Dewey is relating the importance of 'real life' experiences within social contexts for effective learning. During Phase 1 my research data provided evidence that many Year 9 pupils lost interest in school science when the content became more abstract and less relevant to them.

Bruner (1986), influenced by Vygotsky, suggested that knowledge and truth were created, not discovered by the mind, and that the mind was active in the construction of knowledge.

... contrary to common sense there is no unique 'real world' that pre-exists and is independent of human mental activity and human symbolic language.
(Bruner, 1986, p.95.)

This challenged the perception of knowledge as objective and mirroring 'reality' and therefore transmittable in tangible form. Dewey (1929) suggested that subjects in school should be treated as challenges to thought as opposed to objects of knowledge. He asserted that the quality of the mental process rather than the production of 'correct' answers could be viewed as a measure of educative growth (Dewey, 1926). Dewey stated that there was an inadequate understanding of what knowledge was and a sadder ignorance of how knowledge could be made to benefit lives. Carré (1981) along with many others suggested that teachers holding the view that knowledge was

objective were more likely to teach using a transmission style of teaching as this perception of knowledge means that the 'authority' (the teacher) could transmit information into an empty 'container' (*the pupil's mind*).

Dewey also believed that for effective learning to take place the 'quality' of the school experience was key. If the 'experience' was immediately agreeable, pupils would engage with it and this would have a positive effect on pupils' attitudes towards future experiences. This would only occur if the educator selected the:

...kind of present experiences that live fruitfully and creatively in subsequent experiences.
(Dewey, 1938-2nd edition 1963, p.28.)

Dewey argued that some children's experiences at 'traditional' schools were often boring, were foreign to their lives outside of school and consequently fairly meaningless. This was reflected by many of my research sample during Key Stage 3 who commented on the boring and irrelevant nature of many of their school science experiences. Dewey raised a variety of other issues that were commensurate with issues emerging from my Key Stage 3 research findings. The issues he discussed, up to almost a century ago, were associated with individual and unique experiences, active and relevant approaches to teaching and learning, the importance of emotions in learning, individual co-operation and active involvement in the learning process.

The work of Dewey, alongside Bruner and Vygotsky and others, provided theoretical evidence illustrating the importance of the self within the socio-cultural context in the learning process. All argue that knowledge has a subjective interdependence: on an individual's conceptual organisation, on the experiences of the individual and those others participating in the process and on an individual's emotions when constructing knowledge. These experiences reflect the interaction of the individual with their cultural environment leading to dynamic and mutual modifications for all of those involved in the experiences. Bruner stated that meaning making activities could not occur in isolation from the cultural setting and that the very nature of the mind was dependent on the nature of the local culture with its own set of symbols. Bruner emphasised the importance of this

'mutual use' of language with others, within a particular culture, and its effect on learning. He suggested that 'referring' ideas to others provided clarification and led to meaningful learning. He also suggested that *this referral process enabled the individual mind to become active in the reconstruction of a personal perspective about knowledge and about the self.* He argued that:

... most learning in most settings is a communal activity, a sharing of the culture.
(Bruner, 1986; p.127.)

and he saw the classroom as a:

...sub community of learners...
(Bruner, 1996, p.21.)

Bruner (op cit.) also argued that meaning making involves:

... situating encounters with the world in their appropriate cultural contexts in order to know "what they are about". Although meanings are "in the mind", they have their origins and their significance in the culture in which they are created. (p. 3.)

Dewey and Bruner's ideas and arguments have a resonance in explaining a social model of learning and support the notion of intersubjective knowledge.

6.3 The concept of self – esteem

Bruner argued that learning involved the interdependence of cognitive and affective development, that not only were learners socially constructing new meanings but also they were simultaneously constructing new self-images. He stated that these processes incorporated the development of conceptions of the self and individual's position within the culture and that this constructed reality was interdependent with emotions and feelings. Much of the early research into girls' and boys' views about, and engagement with, their school science learning experiences did not link the development of pupil learning with the affective status but only to their cognitive status. Bruner (1989) argued that learning incorporated the individual's interaction with others and the individual's constructions of both what they understood the meaning of the subject to be and how they positioned their continuously developing sense of self in these constructions. He suggested

that individual constructions were key to the learning process and therefore not all pupils would make constructions in the same way. He argued that:

The 'reality' that we impute to the 'worlds' we inhabit is a constructed one. (Bruner, 1996, p. 19.)

Bruner's (1989) view of learning was very much dependent upon the individual both in terms of their own cognitive and affective status. Bruner (1989) also discussed prevailing views on young children's development and believed that cognition, affect and action were viewed as separate processes that interacted under certain conditions. He stated that there was a:

...poverty that is bred by making too sharp a distinction between cognition, affect and action... (Bruner, 1989, p.45-46.)

He later (1996) defined the affective domain as encompassing values, feelings, beliefs and emotions of individuals in their constructions of 'realities' and meanings and that these must be influenced by the particular culture with its own system of values, beliefs and opportunities. In my view it is emotions that provide the critical link between events in the world, including other people, and the individual and these emotions enable an interrelation between internal and external worlds. School science learning experiences must ensure that pupils have the opportunities and confidence to engage their emotions in interpreting and evaluating their learning in school science. This process must be allowed to occur with others and individuals must make explicit connections between their internal and external worlds.

Bruner (1987) stated that the notion of selfhood was characterised both by what a person had already done and what a person could do in the future. He later (1996) argued that this notion of selfhood had two major features, the first being agency. Agency is associated with the view that *one can initiate and carry out activities alone and implied in this is a capacity for initiating and completing acts, therefore skills and know how must be available.* There is a conceptual system that organizes a 'record' of encounters with the world, these encounters are related to the past (the individual has an autobiographical memory) and this helps position the self with respect to previous agentive encounters. There is also an extrapolation to what the possible self can do in the

future and this would lead to a regulation of personal aspiration, optimism and confidence in the individual's capacity for initiating and completing activities and thus influence the nature of individual's engagement with the learning process. He saw a person as having a 'self' with history and possibility'. This notion of the possible self that was interpreted and evaluated by the individual would lead to an individual belief in personal capabilities in terms of success and failure. Bruner (1996) went on to state often it was not the self who was the final arbiter but 'outsiders' using culturally defined criteria to make those judgements. Children encounter 'outsiders' at school, where their performance is judged externally and the child responds by evaluating the self in turn.

The second feature of selfhood is evaluation. Bruner argued that:

Not only do we experience self as agentive, we evaluate our efficacy in bringing off what we hoped for or were asked to do. (Bruner, 1996, p. 37.)

Bruner stated that self-esteem is a combination of agentive efficacy and self-evaluation, that is what we believe ourselves to be capable of and what we fear is beyond us. He also argued that the individual learner needed to be supported, rather than judged, by their teacher and peers in the evaluation of themselves.

Branden (1994) had argued similarly but used the term competence (for self-efficacy or abilities) and worthiness (for values about right and wrong, etc.). He argued that competence and worthiness were equally important aspects of self-esteem. Mruk (1999) also argued that a reasonable definition of self-esteem must:

...account for competence, worthiness, attitudes, feelings and the possibility of maintaining or losing self-esteem. (p. 22.)

He further argued in line with Bruner that self-efficacy involved a relationship between worthiness and competence, that self-efficacy affected both cognitive and affective positions and that self-efficacy was a dynamic phenomenon.

Hannover (1998) stated that pupils developed certain interests to help define their own self-concept and communicated this identity to others that in turn helped them to verify their sense of self. She also suggested that if pupils were interested in the subject, they would make more links between their self-concept and the knowledge domain. She went on to suggest that there were mutual influences between interests that shaped the self-concept and this in turn influenced interest in particular subjects. Individuals with positive self-esteem within a particular domain would choose interests that reflected their developing sense of self and this would serve to regulate their interests. She argued that these interactions between interest and self-concept would influence individual attitudes, expectations and values for school subjects.

Claxton (1997) argued that individual pupils should be given time to reflect on their learning both in terms of their developing sense of self as well as their developing understanding of school science. Claxton (1997) suggested that pupils needed to have resilience that he described as:

...the ability to stick with learning when it gets difficult. (p.77.)

He argued that the effective engagement of pupils in learning would depend on the individual feeling comfortable about making mistakes as well as being able to tolerate anxieties and other emotions during the learning process. He suggested that pupils need to be aware that success, understanding and calmness were all vital to positive self-esteem development. If pupils feel positive about themselves within their learning environment they are more likely to:

...see learning as a challenge, not as a threat. (Claxton, 1997, p.78.)

Driver and Oldham (1986) stated that individuals needed a supportive learning environment in which they could freely express their feelings for active engagement in the learning process. They suggested that the teachers' responsiveness to individual needs and their sensitive mediation of the affective environment was key for effective participation of pupils in the learning process.

Oliver and Simpson (1988) argued that self-concept (as a belief in a personal capacity for success) was key in terms of pupils' individual success in school science. Their study also demonstrated that

affective behaviours in science classrooms were positively correlated with achievement. Watts and Bentley (1989) supported these notions and stated that a non-threatening learning environment had *a very positive effect on individuals' self-esteem and this increased pupil confidence in the learning process.*

6.4 Gender and self-esteem

Gender and self-efficacy interact and effect the relative positioning of girls and boys in school science. My data illustrated a gender difference of pupils' views of their ability in expected success in school science, with boys having a more positive view than girls.

Dweck et al. (1978) reported that the nature of feedback on classwork given to girls and boys was different and this led to girls having lower expectations of success than boys. Licht and Dweck (1987) stated after examination of a large amount of literature on beliefs about intellectual performance that girls relative to boys have less confidence in their ability to succeed. Girls are more likely to attribute failure to lack of ability whilst boys are more likely to attribute their failures to lack of effort. Children who attribute failure to their lack of ability (girls rather than boys) tend in the face of difficulty to lower their expectations for success in the future and they are less likely than others to increase their efforts to meet challenges. Their performance may deteriorate so that they cannot complete challenges they had been able to meet earlier. These pupils have been called 'learned helpless' since they attribute their failure to their lack of ability and this is deemed to be beyond their control (Licht and Dweck, 1987). Boys are also more likely than girls to blame their teacher for their difficulties and this allows them to maintain confidence in their intellectual abilities. Girls more than boys tend not to describe their success in terms of ability but view their success in terms of other factors such as luck. Kelly (1987) linked girls' conscientiousness to wanting to do 'the right thing', rather than to take intellectual risks and this she argued negatively affected self-confidence relative to boys.

Murphy (1989) reported from the APU survey findings about practical investigations in science that when a sample of 13-14 year old pupils were asked how they felt about investigations that *were overtly scientific, about 20% of the pupils, mostly girls, stated they could not do them, that their teachers 'knew' this and they were no good at science.* Also, although girls' performances in the APU practical observation tests were often better than boys, they rated their performances at a lower level than boys. This could be interpreted as indicative of girls' perceived lower levels of self-confidence. Girls and boys reported that they experience practical work differently and Randall's (1987) study concluded that *this contributed to girls' science anxiety and reluctance to participate in practical work.* She also argued that girls had more contacts with their teachers than boys and that the contacts were longer. Girls possibly made more contacts as they wanted to be seen 'to do the right thing' (Kelly, 1987). Randall stated that a lack of self-confidence can be manifested in dependence on the teacher. Whyte (1981) discussed other influences on the positioning of girls and boys and stated that *gendered behaviour (girls' timidity and boys' bravado) together with pupils' self-perception resulted in the pupils' assumption of boys' greater competence in science.* This in turn led to marginalisation of girls in school science laboratories. The APU surveys and other in-depth research confirmed:

...that there was consistent gender differences in pupils' self-images, values and concerns.
(p.334.)

Levin et al. (1987) discussed the notion of affective readiness and its impact on girls in science.

They believed that:

...lack of self-confidence, lack of interest, and low aspiration are quite likely to be manifested by the limited time and mental effort invested by girls when faced with science tasks ... which of course are then reflected in performance. (p.111.)

Clarricoates (1987) argued that:

...girls' real ability is attributed to conformity to institutional expectations, and that the academic achievement of girls in schools is explained in terms of the feminine stereotype. The girls' conscientiousness and diligence makes them 'less bothersome' and 'less interesting' to the teachers who consequently turn all their energies and skills to the boys.
(p.160.)

Kruse (1996) supported this position and stated that girls:

...develop a double strategy of coping in which they convince teachers that they are listening and are present as good pupils while they are actually fooling the teachers. This is their immediate way of maintaining their self-respect, but in the long run they both 'cheat' the teacher and lose out.
(p. 177.)

Hoffmann and Haussler, (1998) argued that:

...interests are mental representations that are strongly linked to self-related knowledge...interests are used to regulate self-esteem and... interests and self-concept mutually influence each other.
(1998, p. 303-304.)

Girls' lower self-efficacy relative to boys' can often result in a low science self-concept, which in turn can limit the development of interest, and engagement with, school science.

6.5 Methodology

The literature on learning and the self presented in this chapter helped me to construct my next period of data collection. The importance of individual construction and re-construction of meaning within social contexts reinforced for me the need to examine aspects of pupils' feelings and more importantly to see these feelings as individual, dynamic and flexible. I argue that individual pupils' self-efficacy is of immense importance in the learning process. I felt that I needed to prioritise listening to the pupils to enable more of their personal understandings about their school science learning experiences to emerge. At this stage in my research I decided that I needed to continue to talk with pupils over a long period of time so that I could develop a clearer understanding of the factors influencing their learning and the way in which individual pupils did or did not manage to resolve the impact of these influences on their disposition towards school science. From the literature and listening to pupils I have developed a clearer understanding of the importance of the self and the way in which the affective and cognitive domains affect the positioning of pupils within the learning process. From the earlier data the major issues emerging as key influences for my research were:

- Perceived levels of active involvement with school science;
- ineffective pedagogical practices;
- perceived levels of ability in doing school science;
- teaching and learning relationships and the affective environment;
- level of autonomy allowed in learning;
- lack of time for effective learning;
- relevance of, and interest in, science knowledge.

In addition the major issues arising from the literature were:

- The centrality of pupil self-esteem in the learning process;
- the uniqueness of each pupil's experiences;

- the social nature of learning;
- the interdependence of cognitive and affective factors;
- *the need for the learning environment to be supportive of pupil learning;*
- intersubjectivity –is there shared meaning with the teacher for all pupils?

My concern is therefore to understand at an individual level:

- What factors continue to influence the development of pupils' attitudes towards their school science learning experiences?
- How pupils perceive that their school science learning experiences could have been improved?

To achieve these aims I decided to adopt a case study approach where the individual pupil was a 'case' and to represent their understandings as a narrative account as reported by them and confirmed by them.

6.5.1 A case study approach

Stenhouse (1978) suggested that case study was an approach that tried to understand the situation as a whole. By talking with pupils over a five-year period I recognise that each pupil's view of school science has a past and a future that is a part of their whole life experience. I have an interest in exploring the similarities and differences between the individual cases and between boys and girls. Simons (1996) reported that *if we explored in depth the real understandings associated with case study, both unique and universal understanding would emerge. Understanding each case requires:*

...an understanding of each one's uniqueness. Uniqueness is established not particularly by comparing it on a number of variables... but the case is seen by people close at hand to be, in many ways unprecedented and important, in other words, a critical uniqueness. (Stake, 1995, p.44.)

Like Merriam (1991) my case studies will be descriptive and interpretative. My aim is to offer a subjective description of events that will lead to further reflection for the reader and myself. Like Altheide and Johnson (1994) *my intention is to provide accounts that will communicate with the reader a subjective reality about individual pupils as I begin to understand them. I feel challenged because I will have to resolve my uncertainties about my own knowledge and criteria of knowing. Simultaneously I will be trying to clarify meaningfully the nature, processes, importance and consequences of the ways in which my selected pupils define their situations. I have emphasised my subjectivity and the relativist nature of the 'knowledge' produced (Stanley and Wise, 1993) from case study but I believe that my stories will contribute positively to knowledge about pupils' school science experiences.*

It is implicit in the notion of case study that there is no one true definition of the situation. Within the confines of the study we act as though truth in social situations is multiple: the case study worker acts as a collector of definitions, not the conductor of truth.
(Walker, 1994, p.192.)

Hammersley (1992) stated that personal accounts were more valid if they represented accurately those features of the phenomena they were intended to describe, explain or theorise. Hammersley (1993) also reported that case study research often relied on face validity and described this as being:

...the judgement that the results seem to fit the reality. (p.178.)

In case study face validity has significance as the researcher continuously endeavours to portray how the researched perceived the situation.

Pupils necessarily hold a variety of perspectives on their school science learning experiences and thus their narrative accounts will be complex representations of these experiences.

6.5.2 Interviewing pupils

During interview I plan to allow each pupil time to create and transform their unique understanding associated with each of the interview cues (questions). Not only will pupils interpret the meaning

of questions differently; they will also have to place those meanings within their own particular contexts, with respect to their prior learning experiences and other social experiences. Pupils will be supported in developing their own meaning systems with respect to the interview cues and will be given the opportunity to develop their individual answers using their peers (and occasionally myself) during the interview. Pupils respond quite differently to the same questions, as they perceive different dimensions of the questions as important to them as individuals.

Processes of reflection, rather than rule-based interpretations (Greenwood and Levin, 1994), will be set against a background of data from a number of sources - interviews with pupils, school reports, national assessment information and records of achievement. The documentary data will be used alongside interview research evidence to provide a broader picture of the pupils' school science learning experiences and this should lead to further meaning making.

There were sufficient commonalities in response, to both the survey and interview, from pupils across all three schools for me to be able to focus on pupils from one school. As I want to progressively focus on a smaller number of pupils I decided to continue to interview twenty pupils from one school. In selecting individual pupils for in depth, longitudinal research, I selected those I was most familiar with, who attend a school I had taught in, who were taught by colleagues of mine and were girls and boys studying science at different levels for external examinations. These pupils were a sub-set of pupils selected in Year 7 at the beginning of my research.

Key issues emerging from the earlier data and the literature were used to develop the interview schedule for Key Stage 4. I re-constructed the pre-interview questionnaire (see appendix 11) to allow the pupils to elaborate what they considered to be important and salient to them so that I could look for what was important to the individual. The pre-interview questions focused on: GCSE science courses, positive and negative aspects of the course, pupil levels of confidence, their course expectations, how they felt about coursework, their level of understanding, relationships

with teachers, their progress in terms of understanding and effort and factors affecting their level of personal motivation.

I took a more facilitative role rather than directive in the interview discussion to allow individuals the time to develop their ideas more fully. During interview I used the pre-interview questionnaire as the interview schedule and could therefore compare group responses with individual responses. Although the interviews were semi-structured, using the pre-interview questionnaire they were *informal and allowed more possibilities for unexpected insights and changes in direction*. The interview questions were designed for me to probe pupils' thoughts and feelings about their examination courses in science as well as within other subject areas so that more information about individual pupils could emerge within the context of their whole school experience. The issue of self-efficacy (self-image/esteem) emerged from the literature in Chapter 6 as having a central role *in the positioning of pupils in the school science learning situation*. My first interview question asked pupils to discuss their perceived levels of self-confidence at the beginning of their GCSE courses, generally and specifically within science. I expected diverse responses that would illustrate the uniqueness of pupils, both in their interpretation of the question and the nature of their responses. Question 2 asked pupils to reflect on positive and negative factors influencing their learning at GCSE level, I prompted pupils to think about the content, interest, the role of their teacher and practical work. These prompts were selected as a natural development from the key issues emerging from earlier data. Question 3 focused on pupils' personal expectation for success. In asking this question I wanted to further explore pupils' self-esteem and factors affecting this; I expected the role of the teacher and its' effect on personal expectation may emerge as a key issue in pupil response. Question 4 asked pupils about the impact of practical-based coursework (as this would count for 20% of their final grade) and how this affected their learning in school science. Questions 5 and 6 focused on their perceived levels of confidence in their final examinations. Question 7 was about the volume of work associated with school science. This question was included as the earlier data illustrated that pupils had concerns about the amount of content to learn in science and the lack of time for practical work and discussion. Question 8 asked pupils about

their understanding in school science. I expected that girls would be more concerned about their personal level of understanding than boys, as research suggests that girls have a tendency to seek 'connected knowledge' (Staberg, 1994), whereas boys tend to be more content to learn isolated facts. Question 9 asked whether pupils had the same teacher for all of their science lessons. This question was asked because the importance to some pupils of pupil-teacher relationships that emerged in earlier interviews. Question 10 and 11 developed from question 9 and asked whether pupils felt teacher relationships impacted on their learning in science and whether their present science teacher had taught pupils during KS3. As in question 2, I used prompts informed by the literature and the earlier data, for example about levels of teacher support, explanations, etc. Question 12 asked how pupils felt about how well they were doing in their GCSE courses in terms of their achievement and understanding. This question was asked so that I could further explore issues associated with pupil self-esteem. Question 13 asked whether pupils felt their work at KS3 had aided their understanding at KS4. Here I was looking for responses from pupils that illustrated the effects of prior learning experiences and its effect on understanding at individual levels. Questions 14 and 15 asked pupils to discuss what factors were motivating their learning in school science I was hoping to explore issues about what factors were important to them in their expected success in school science.

I distributed a pre-interview questionnaire (see appendix 11) in the first month of Year 10 at the beginning of the pupils' GCSE courses. I interviewed pupils approximately 6 weeks later in the same groups of four they had been interviewed in previously. I decided to continue to interview pupils in their original friendship groups of four as prior experience in the study showed that the presence of peers in the interview provided support for pupils to develop their responses to my questions.

Each interview lasted about one hour and took place in their Year Head's room during lesson time. I met with the same pupils on five occasions over their compulsory secondary schooling and I feel that this enabled pupils to become more used to articulating and developing their ideas with me.

Pupils were encouraged to reflect back on their previous responses and as they became older they were able to articulate more clearly their thoughts and overall views.

I repeated the interview process in Year 11, but distributed the pre-interview questionnaire in the January of Year 11 and interviewed the pupils six weeks later.

6.5.3 Selection of cases

From the original group of twenty pupils interviewed over the five years of their compulsory secondary school experience, I selected 10 for in-depth case study. The ten pupils I selected comprised five girls (Natasha, Beverley, Hayley, Sian and Samantha) and five boys (Zahadil, Chris, Stephen, Alan and Stan). These pupils all attended School 2, a multi-cultural Community College, in Coventry, England. The school science department teaches all pupils in Year 7, 8 and 9 in mixed ability groups. The curriculum in Year 7 and 8 is taught as General Science and in Year 9 science is taught as three distinct disciplines (physics, chemistry and biology). There is one teacher for each mixed ability class during Key Stage 3. At Key Stage 4 there are either two or three teachers per teaching group. Although there were some indications of possible differences between co-educational and girls' only pupils in terms of how important school science was to them, I was more interested in selecting pupils for the final stage of my research from the most likely setting that would provide most information about the formation of attitudes towards school science. Co-educational schools are the dominant type of school and therefore more representative of the population than single sex schools.

The selected pupils were all studying GCSE science either Double Award GCSE science (2 girls, 2 boys) or as three separate sciences (Triple Award, 3 girls, 3 boys). The Double Award candidates will finally achieve two grades for GCSE science; the separate science (Triple Award) candidates will finally achieve three grades with a separate grade for each of the science subjects. By the end of Year 11 there was some movement of pupils in different groups. Two of the separate science

pupils (1 girl, 1 boy) were entered for Double Award science in Year 11. Two of the Double Award pupils (1 boy, 1 girl) were entered for Single Science Award in Year 11.

Table 6.1 The cases by gender and course of study.

Name	Gender	Science course of study
Natasha	F	Triple Award
Hayley	F	Triple Award
Beverley	F	Triple Award
Sian	F	Double Award
Samantha	F	Double Award
Alan	M	Triple Award
Chris	M	Double Award
Stan	M	Double Award
Zahadil	M	Triple Award
Stephen	M	Triple Award

Natasha, Hayley and Beverley were friends from one mixed ability teaching group in Year 9, all of whom had eventually been directed by their teacher towards the study of Triple Award science for GCSE. They all enjoyed science at KS3 but differences in their views of their school science learning experiences began to emerge in Year 10. Sian was selected because although she enjoyed science at KS3 she could not really understand why she had to continue to study it for GCSE. She studied Double Award science at GCSE. Samantha was selected because although she enjoyed science at KS3 and was placed in a Double Award science group she did not enjoy her science studies in KS4. Stephen and Zahadil were in the same mixed ability class as each other during KS3. They were both directed to study Triple Award science. Stan, like Sian, was selected as a Double Award candidate who was not particularly interested in school science but thought that it was an important subject for life and his future occupational choices. Alan enjoyed science and was being entered for Triple Award science examinations. Chris enjoyed science in Years 7 and 8 but he lost interest in school science during Year 9. Chris, like Samantha, was entered for Double Award science in Year 10.

6.6 Analysis

The analysis of the individual pupil responses was quite different from the analysis of data for Year 7, 8 and 9. There was a shift to a focus on the individual. The notion of uniqueness was central to

my analysis; both the uniqueness of what individual pupils said and the importance they gave to certain things. I consistently included pupils' initial responses to my questions and also presented developed responses if these were focused on issues arising from earlier data and from the literature. I became aware of the uniqueness in pupil response to the same dimension (for example teacher explanation) and the way in which individual pupils gave value to different aspects of their school science experience and incorporated these into their narrative accounts.

A vast amount of individual material was collated and I selected the material that provided me with the essence of the individuals' experiences. Like Millar (1997) I wished to write small summaries highlighting distinctive features of each selected case. I perceived each case as:

...being as close to the real world [of the pupils] in a way that research produced by orthodox experimental design or survey research [cannot]...(Walker, 1994, p. 175.)

The narrative accounts were written using a range of data sources including interview, questionnaire, pre interview questionnaire and documentary data. I weaved together available data from a variety of sources for each case. I used exemplar material from the Year 11 interview transcripts to give the final pupil position more directly with respect to their school science experiences. I did not use exemplars from earlier on as this would have been too cumbersome and the accounts would have been over long. The narrative accounts in draft form were returned to individual pupils (when they were in Year 13 at school or in other occupations) and they were asked to comment on the accuracy of their accounts and to make further comments if they wished. This was intended to increase the validity of the stories through triangulation. I distilled the content of each narrative as I reviewed the whole data. Much data was necessarily left out and hopefully I provided an account comprehensible for any reader to construct his or her own meanings. These narrative accounts were also used to highlight changes over time for individual pupils.

Chapter 7 Pupils' experiences, dilemmas and resolutions about science.

In this chapter I present the case study data collected from 10 pupils at school 2 who were involved in the study from the beginning. I identified twenty cases initially and then examined the narrative accounts to select a sample that would represent two aspects of my argument. First I wanted to demonstrate that there were common influences that pupils' reported affected their learning and engagement in science. Second that individual pupils accord different value to aspects of these influences and this alters the nature of the dilemmas they experience in their learning. Individuals may therefore make the same decision about studying or not studying science but to understand that decision it is necessary to see how these different values emerge in their accounts of their experiences. My argument is that if teachers are to know how to act to retain pupils in science and/or to improve their learning experiences they need to understand the influences that pupils identify, individual responses to these and the consequences for pupils' evolving self-esteem as science learners.

In the chapter I present the narrative accounts and then I examine the unique resolutions that individuals appear to make and relate these to their future life choices and the role of science within this. Finally I consider what is common in pupils' accounts about what serves as a positive influence on their science learning and what they considered negative influences. In the accounts it is clear that pupils' achievement has no single direction of influence. The accounts vary in detail and this largely reflects individual's level of involvement during interviews and subsequently when I asked for information and when I returned the accounts to pupils for them to verify. For example I asked pupils for copies of their Records of Achievement and only a small number of pupils made these available to me. I returned the narrative accounts to the pupils for comments but only a few pupils responded. The ten pupils I selected comprised five girls (Natasha, Beverley, Hayley, Sian and Samantha) and five boys (Zahadil, Chris, Stephen, Alan and Stan). The names are pseudonyms. Natasha and Zahadil were selected as able pupils by their teachers with a keen interest in school science and who had expressed early on a desire to study science subjects at

University. Hayley and Alan were selected because they were viewed as able pupils and were studying separate sciences at GCSE but expressed early on that they had no intention of studying science after GCSE. *Beverley, Chris, Stephen and Samantha were pupils who began secondary school with very favourable views on their school science experiences but lost interest for a variety of reasons during Year 9. They were all moved to a lower level of study during their GCSE courses (Beverley and Stephen from separate science to Double Award and Samantha and Chris from Double Award to Single Award). Sian and Stan were selected as typical Double Award science pupils*

7.1 Zahadil

Zahadil had high self-esteem as a learner in science and was very confident with his science studies at Key Stage 3. He stated that out of school he learned a lot from encyclopaedias and he enjoyed home study. In Year 9 he stated that he would like to go to college to study A levels in chemistry, biology and physics so that he could study medicine. Even though Zahadil was confident and articulate he was a rather shy and reserved pupil. He felt that he was very good at science and liked science when it was structured and clear. He considered that he learned more by doing active practical work rather than writing. He did not like doing experiments with easily predictable results as this was not a challenge. He did not like the lack of time for sharing results and for completing experiments properly. He felt that they were given too many directions from the board for experiments and that he should have been allowed to work things out for himself more. He also felt there was too much bookwork which he found unchallenging and boring. He would have liked to have worked more autonomously. All of these features of Zahadil's experience point to his concerns about how his agency in learning was being undermined. From Zahadil's account agency was important both for his motivation and interest as well as his ability to learn and progress. The two were not separable.

He preferred physical science to biological science topics in Year 8 and in Year 9 he preferred chemistry to biology and physics. He achieved a Level 6 in his SATs test.

In Year 10 he studied the three separate sciences and he expected that he would achieve grades B/C in physics and chemistry and grade A/B in biology. His teachers expected that he would achieve grade B in all three subjects. *At the beginning of his Triple Science GCSE course Zahadil felt nervous but overcame this by working hard in school and at home with the support of his family. He felt that sciences were his strongest subjects and was confident he could do well.*

I found all of them [science subjects] particularly difficult, but as I progressed I found that I could understand it more. I think I was just nervous, starting the course. But I overcame that.
(Year 11, line 206.)

He was very enthusiastic and interested in studying science at this level, because he found the subjects more interesting and he felt that his understanding had improved. Again Zahadil points to the important relationship for him *between interest and understanding - the growth of one depends on the other*. He felt that his teachers were very thorough and they had helped his understanding. The teaching was excellent as he felt there were better explanations, which he saw as pivotal to understanding. At this stage he felt that he learned a lot whilst doing practical work in groups because sharing ideas in groups provided him with a lot of feedback. Here again Zahadil points out his understanding of what he needs to learn, it is not clear that his teachers understood this. *He had good relationships with his peers, found them supportive and challenging and they were all actively involved in learning. He still wanted to study sciences at university.*

In Year 11 there began to emerge differences in Zahadil's view of his competence, and his interest and liking for science subjects. He continued to be very confident with all of his school subjects but had begun to lose confidence in biology and chemistry *despite retaining a positive interest*. His teacher estimated a B grade in biology, A/B grade in chemistry and an A grade in physics. He continued to be confident in physics, but did not like the subject anymore, as there was too little practical work. This was in spite of his view that he understood more in physics now than he had in previous years. He explained his loss of interest in physics:

Z¹ *I don't like my physics teacher*

R *Why not?*

¹ Z represents pupil comments; R represents researcher comments.

Z *He just makes you write off the board every lesson, like, no experiments...*
(Interview 2, Year 11, lines 91-93.)

However he continued to be challenged by his science studies and enjoyed the practical work as he felt he could learn more for himself because he was actively involved in his learning. Science continued to be an important subject to him. When Zahadil had difficulties with some of the science content he worked harder to improve the level of his understanding and he did this with support from home. He achieved a grade A in his physics mock examination and grade B in chemistry and biology. He was disappointed because he wanted to achieve A grades in all three subjects. He felt that his teachers needed to be stricter, more efficient and interesting but he continued to believe that the level of teacher support, explanation and commitment was good. He suggested that teacher relationships should not affect individual learning but that they did. His view about teachers was that:

...if they're stricter, you're more likely to do the work.
(Year 11, line 350.)

For Zahadil the fact that his teachers were not strict did not affect his level of work because he was intrinsically motivated to be successful in science.

He did not like copying from the board and he suggested:

Z *Well, I think the teachers could be trained more to make the teaching more efficient.*

R *How do you mean more efficient?*

Z *Like...they'll just write things on the board but make you learn yourself.*

R *So, ban board writing?*

Z *Well not ban it totally, but make it more interesting.*
(Year 11, lines 423-426.)

He also stated that to make science more interesting there should be more practical work and:

I think mainly you just do work that involves the student more. Not just the teacher talking all lesson. (Year 11, line 453.)

He achieved B grades for all three subjects at GCSE. He studied biology, chemistry and maths at A level and went on to study pharmacy at university.

7.2 Natasha

Natasha had high self-esteem as a science learner and reported that she was very confident in her science studies throughout Key Stage 3. She wanted to become a doctor and had therefore an intrinsic motivation for, and interest in, school science. *Like Zahadil she enjoyed practical work because she felt this enabled her to learn more autonomously.* She also enjoyed groupwork and discussions, as she believed these activities allowed her to share her ideas and clarify her own understanding another feature of an agentic learner. Like Zahadil, Natasha was aware that if she enjoyed particular topics she learned her work more thoroughly. She was a very reflective pupil and would work at home to reinforce her understanding and *she felt secure that she was developing a good understanding of school science.* She was a very articulate pupil and was concerned about her science learning experiences and valued the opportunity to share these concerns during interview. She preferred biological science to physical science topics in Year 8. She disliked copying work from the board and poor teacher explanations as these undermined her learning. There were times when she felt her teacher provided too much information. Implicit in these comments is *the view that Natasha preferred to set herself personal challenges and to be an agentic learner and to feel that she was understanding and achieving what she hoped.* By Year 9 Natasha had developed a dislike for physics as she felt she did not understand it. She attained a Level 7 in her SATs test indicating that she was a very able pupil.

At the beginning of her Triple science GCSE course her teachers estimated that she could achieve grades A or A*. She felt confident she could achieve at this level, but felt a little apprehensive about her GCSE courses. She continued to enjoy biology and chemistry. She liked the way in which her biology teacher outlined the course content at the beginning of the year and also spent time assessing individual pupils' prior knowledge. In both cases these actions made the learning journey for pupils transparent which is essential if pupils are to be in control of their own learning and experience agency.

Although Natasha enjoyed biology she felt her test marks were not very good. In chemistry she felt that she had understood the subject more this year than previously. She found physics difficult and felt that she did not understand the subject and that she had lost confidence in her abilities. Reasons she gave for her

difficulties were that teacher explanations were poor, the teacher did not go over the work, that there was not enough interactive teaching, too many demonstrations and not enough group practical work. She felt that *her physics teacher did not understand her difficulties particularly whilst studying forces, motion, energy and weight topics*. Natasha also stated that she found it hard to answer test questions in physics when the questions were set in a context. She said that she could use numbers and formulae to work out answers but found contexts confusing. For example she stated that she found it very easy to substitute numbers into formulae and carry out a calculation, but when the numbers for a forces calculation were related to *stones falling off cliffs she found it more difficult to complete the calculation*. This relates to other research findings where trying to understand contexts outside of their experience can create barriers for pupils (Murphy 2000).

She thought that her Key Stage 3 teacher had been very good and helped her understanding at this level. In Year 10 she felt that her science teachers did not know her well and she found developing new teacher relationships difficult. Natasha enjoyed the coursework associated with GCSE science as she felt this demonstrated her understanding at an individual level. She worked hard, enjoyed her work and this motivated her. She found the pressure associated with being in the 'top group' a very positive experience.

Her end of Year 10 school reports were exceedingly positive. Her self-evaluations were very positive in biology and even though she had some difficulties she felt that she worked hard at overcoming these and felt confident that she would be successful in this subject at GCSE level. She felt fairly positive about chemistry but she felt that she lacked confidence in some topics, she found physics the hardest science subject because she did not like it. At the beginning of Year 11 her teachers still estimated that she could achieve A or A* grades in her GCSE science examinations. She continued to feel very confident with biology and fairly confident with physics and chemistry but in physics she felt the teaching was too rushed and this made the work difficult.

Overall she still enjoyed her science studies but had problems with two of her teachers. In biology she did not like having to copy many notes from the board. She did not like the feeling of being rushed through the syllabus in biology, even though it was her favourite subject:

It's like the syllabus is the bible, and all we do in lessons is either copy out, off the board, and she's writing up, copying the syllabus on to the board, we copy it. Either that or she dictates to you, and that's it. Copy it down and we're finished. We don't go back to it.

(Year 11, line 52.)

I have to go home and read it up myself, again and again.

(Year 11, line 54.)

She did not like the style of teaching or the personality of her physics teacher.

N² *I just don't like the teacher in physics*

R *Is that in terms of personality or in terms of how they teach? Or are they sort of inter linked?*

N *It's a bit of both really.*

R *What about the content of physics, do you understand that?*

N *Some of them I do, but because of the way it's taught, and because sometimes things go over my head, I'm less likely to understand in physics...I'm getting a bit confused with physics.*

(Year 11, lines 62-66.)

She found physics the least interesting of her science subjects, partly because she did not understand and because she was not interested in it. She again suggested that topics were covered too quickly and that there was insufficient time to consolidate her understanding. When asked which particular physics concepts she found difficult she responded:

We did do stuff about electromagnets and electronics...we did it really quickly, we didn't get chance to sit and think about it, transformers it was...we did that in about half an hour.

If she spent more time...and do past papers...and experiments...

(Year 11, lines 68 and 70.)

She found the Left Hand Rule incomprehensible, magnetism, speed, velocity and acceleration very confusing and she found these topics least interesting. Here Natasha is highlighting the way that interest and motivation are related to engagement. It is a typical finding of research into gender differences that

² N represents pupil comments.

aspects of physics outside of girls' everyday experiences are not initially interesting as girls consider they lack knowledge of them and have no insights therefore into their relevance. This limits pupils' engagement, which further reduces their interest in these aspects of physics and the possibilities for their learning about them. Once more Natasha complained that there were very few experiments, little discussion time and consequently felt she did not understand the work. She felt that the teaching was too rushed, there was no continuity from lesson to lesson, there was not enough time to think or reflect on her understanding and there was too much copying. She would have liked to spend more time discussing her concerns and clarifying her understanding. Again all of these factors point to the way in which Natasha experiences physics as being out of her control as a learner. She felt that her physics teacher saw her difficulties as Natasha's responsibility alone:

In physics she just seems to look down on you. You ask a question, she like, well I should know, [because she had] just explained that.
(Year 11, line 114.)

She goes [says] well if you don't understand it you should not be in this group..she didn't try to explain it...
(Year 11, line 117.)

It's just science that there's problems in. Nothing like in geography... maths, English. Nothing else is like this, it's just science. And the teachers as well. Just the science teachers...
(Year 11, line 244.)

...that does annoy me as well...because science is my favourite subject.
(Year 11, line 246.)

Natasha said:

Miss XXX came back ... here's the equipment, do the practical. No introduction or anything
(Year 11, line 373.)

She felt that her physics teacher:

...doesn't seem to care really.
(Year 11, line 334.)

She felt that the organization of coursework timetables was poor, as she had to complete a number of assignments at the same time as sitting her mock examination papers.

She eventually achieved grade A in physics and biology and grade B in chemistry in her GCSE examinations. At A-level she studied maths, biology and chemistry. Although Natasha had four university offers to study medicine, she decided she did not want the pressure associated with medical studies and went to university to study for a BSc in Human Biology.

7.3 Chris

Chris was another pupil with high self-esteem as a science learner at Key Stage 3. He really enjoyed being active in practical work in groups and found science very interesting and exciting. In common with other pupils he would have liked to study more biology, to do more research work, to study more about technological developments and to do more novel experiments (rather than predictable ones). He also stated that he would have liked to take more things apart, for example telephones and televisions, to see how they worked. This liking for tinkering activities has been cited in gender research and is related to both boys' perception of what is relevant and their experience of out-of-school activities where boys more than girls report being involved in taking things apart etc and choose to engage with such activities when given the choice (Brown and Ross 1991). Having opportunities to explore science issues through such activities has a positive impact on boys' learning. Chris enjoyed studying physical science and biological science topics equally in Year 7 and 8. By Year 9 he found his science experience had changed, with too few experiments which he felt limited the role he could play in his science learning. At this point, he enjoyed biology more than physics or chemistry. He achieved a Level 5 in his SATs test.

At the beginning of Year 10 Chris stated:

Year 7 and 8, I liked it [science] because it was something new. Then around Year 9 I started losing it, because like it started to get a bit boring. Year 10 it was just like we didn't do much practical work. We were just doing more on the writing side.
(Year 11, line 37 and 39.)

In Year 10 he started studying Double Award science and expected to achieve a grade B/C, his teacher estimated that he would achieve a C grade. He was still confident with his science studies although he said he found it boring. This appeared to be related to his finding the work much more difficult to understand mainly because of the lack of practical work and poor teacher explanations particularly in biology and

chemistry. He felt that he understood most of his physics but hardly any chemistry. He said he was losing motivation for science and this was linked to there being a lot of work to do in science and this stressed Chris particularly when he did not understand things. In Year 10 he did not associate this with his teachers as he said his biology/chemistry teacher understood his difficulties and that his physics teacher was good at explaining concepts.

By Year 11 Chris felt that he could achieve a grade B in biology, grade C/D in physics and a grade D in chemistry. This indicated that he was still confident in biology, less confident in physics and significantly less confident in chemistry. His teacher estimated that he would achieve grade D in Double Award science. Maybe this low teacher expectation had a negative impact on Chris' motivation for studying science. He stated that he was very bored with science because he felt that he needed more teacher explanations rather than working out of books and he would have preferred to be more active in his learning. He referred to the pedagogical style of his teachers (using books frequently) as affecting his learning:

I don't like that. You know, I usually find myself chatting most of the time to people in the class because the way he's doing it is just rubbish.
(Interview 1, Year 11, line 146.)

He suggested that his relationship with his teachers was sometimes good and sometimes bad, this was probably associated with his changing levels of interest and commitment. Like Zahadil he felt he would have worked harder if his teachers had been stricter.

If he's [the teacher] more strict with you, you learn more...
(Year 11, line 108.)

If you've got a stricter teacher you work a lot harder than you do with the more lenient teacher who has a laugh with you.
(Year 11, line 383.)

He felt that his school science experience would have been better if he had worked harder all the way through Key Stage 3 and 4. He began to lose commitment to his studies and felt that he would have worked harder if his teachers had 'pushed him' on and if he had not found much of the science content boring and difficult. His lack of commitment and effort to complete his work effectively in Double award science eventually led to his teachers moving him down to the Single Award group. His results for his Double Award mock exams: chemistry as expected, physics better than expected and biology worse than expected.

He felt that about half way through Year 11 that he was trying very hard to catch up with much of the work across all subjects.

But he also felt that his school science experience should have been more related to his future life:

I think they [teachers] should have shown what science will actually do to you in the future. As in job aspects. Because if you know what you want to be, they could point out what things you really need to work on hardest – out of the sciences or something like that. Which gives you a greater chance...so to give you an idea of the sorts of... the valuable nature of science, apart from the obvious ones like health, light and things.
(Year 11, line 359.)

He was losing interest in science because his school science experience was not related to his future and he could not see the relevance of much of the course content and he felt that he was not very good at it:

...Science is a bit dodgy, because I'm a C/D borderline, so, I mean I enjoy doing it but I lose interest because I'm not that good.
(Year 11, line 132.)

Chris felt that he was not working well this year because he lacked commitment and had difficulties finishing his coursework on time, even though he took days off school to try to complete it. He felt that he understood biology because he found the work interesting and thought he could achieve good marks if he enjoyed the work. He found much of the physics content boring, particularly electricity, and felt that he did not understand much of the work in chemistry.

C³ *Real equations and all that lot. Don't like them at all.*

R *What do you mean, all that lot?*

C *...word equations as in mixing copper and tin and like putting them in a ...*

R *...Symbols and things?*

C *Yes periodic [table] I don't like that.*
(Year 11, lines 163-167.)

Chris, like Zahadil, thought his teachers should have been more strict but his response to this was quite different to Zahadil's. Chris took advantage of his teachers' leniency and did not work very hard at all. For Chris there was no evidence of or reference to support that he received from home. His form tutor

³ C represents pupil comments.

suggested that he had 'limited support' from his family and Chris began to 'fall away' from science as the opportunities for him to learn were becoming increasingly limited. Consequently he found the work more difficult and more boring and his teachers did not seem to notice his developing lack of commitment. His learning was eventually completely constrained by the move down into the Single award group. The dilemma for Chris in relation to his learning in science he was unable to resolve except by giving up and consequently his achievements were limited. However his teacher, not Chris, decided his future science learning. His teacher read his behaviour as lack of effort and engagement in science that was attributed of Chris rather than the subject or its teaching.

Chris would not have dropped his study of science given the option because he felt that it was an important subject for future employment opportunities. He achieved a grade D for Single Award science. He planned to study graphics and PE at A level.

7.4 Beverley

Beverley was very confident with her school science studies at the beginning of Key Stage 3. She felt that she was good at science and found it easy. She enjoyed being actively involved with practical work and felt she could retain information more easily if she had completed the work herself. Beverley along with other pupils had made a link between the quality of her learning and the opportunities for her active engagement in it. If she made mistakes her teacher would help her and she felt that this aided her understanding of the content. She felt more confident when she was working in groups. In Year 8 Beverley complained that her teacher lacked enthusiasm for her subject and did not provide the same level of support as had been given in Year 7. She also said there was too much copying from the board this year, this undermined her autonomy in that she preferred to be actively involved and wanted to work more independently of the teacher. She preferred biological science topics to physical science topics.

By Year 9 Beverley was losing interest in physics as she felt that it was not relevant to her, particularly electronics. This is an established area of concern for girls and has been related to their experiences out of

school that lead them to perceive certain activities as beyond their realm of competence (Murphy 2000). She did not like planning her own experiments because it was too time consuming and she preferred being told what to do by her teacher. *This is somewhat in contrast to Year 8 where she expressed a need for more teacher support, but also valued working independently.* Beverley appeared to lack confidence in herself as a science learner and felt she needed teacher support to achieve well. She did however appear confident on the surface having a bubbly personality. This may have influenced the teacher's view of her needs and led to insufficient support being made available. In response to this Beverley sought more, not less help. In responding to this *the teacher inadvertently limited the opportunities for Beverley to engage with her work independently.* This appeared to explain why she became bored in science and felt she did not understand it. She was also becoming bored with science because there was too little time to reflect on what she had been studying and she found it hard to understand the teacher's explanations. These experiences meant that she was beginning to lose belief in herself as a competent learner. She achieved a Level 5 in her SATs test. *This is regarded as average for the population of 13 – 14 year olds.* Beverley stated that at this stage she had no intention of studying science subjects post 16.

At the beginning of her Year 10 Triple Award science GCSE course, her teacher estimated that Beverley would achieve C or D grades in all three subjects. Beverley predicted that she would achieve C grades. She felt very worried that there was too much work to do in too little time and therefore she could not deepen her level of understanding. She was beginning to feel confused and continued to feel that she was not very good at science. She still enjoyed the practical work as she felt she could reflect on her work and like other pupils, this helped her to learn and understand more. In her experience, along with other pupils, talking during group practical work helped her to learn more. The amount, and quality, of teacher talk in chemistry particularly put off Beverley. She explained that the teacher wandered off the subject and provided poor explanations. In addition there was too little practical work and too much writing. She also stated that the topics in general were too short and that she needed more time for reflection to reinforce her understanding.

She found the biology worksheets unclear and felt that the teacher did not spend time clarifying the work, and because of this she judged that her level of understanding was poor in biology. She argued that her biology teacher gave explanations whilst they were copying down the work and this was not conducive to supporting her understanding because of having to concentrate on more than one thing. Also in biology she did not feel that homework was relevant to the schoolwork. Beverley said she needed much more teacher support and wanted her teacher to provide the support without her having to ask for it. She added that good teacher relationships were important and felt her teacher did not know her or understand her difficulties. She said that her biology teacher had favourites and only taught the pupils in the front row.

She felt that her physics teacher did not listen and made her feel uncomfortable about asking questions. In Beverley's opinion her teachers should have asked the pupils more questions to assess their understanding, and if one pupil answered a question correctly they should not assume everyone in the class had the same level of understanding. In her view her teachers were too busy and did not have the time to accurately assess individual understanding. Beverley wrote on her pre-interview questionnaire that:

I have found it very hard to understand science and have needed personal attention from the teachers, which I was unable to obtain. (Year 11, PIQ, p.1).

She commented, in a similar vein to Natasha, that her teacher in physics did not understand or respond to her difficulties suggesting that the problems for learning rest with the pupil:

...and when they say obviously...the more I personally go "oh so that is another thing I don't know".
(Year 11, line 118.)

Beverley achieved a grade D in her mock examinations for each science subject in Year 11 as she expected. Her teacher estimated grades were D. By Year 11 Beverley described her position in science in the following way:

B⁴ *I don't enjoy science now at all...It doesn't interest me as much as it did before, and I'm not as interested myself.*

R *What do you think has led to this change in interest?*

B *I didn't like my teachers. For two of them, I don't like the way they teach at all, their personalities, but my other teacher (chemistry), he's fine really.*

⁴ B represents pupil comments.

(Year 11, lines 4, 12, 14 and 18.)

She commented:

It's a shame when you sit here listening to us all, saying this though, because like, if you'd have said this in year 7 we'd all sit here and go "we love science, it's one of our favourite subjects, and we like the teacher" ...

(Year 11, line 146.)

She went on to comment:

When you don't like a teacher...you can't ask questions because you don't think you're going to get a sensible answer without "obviously" or "you should know that". So the more you get that the more you don't want to try. Then when one science is going down...it does affect the other two...

(Year 11, line 155.)

She commented that if her teachers did not present information in an interesting way:

...if the teacher's not teaching it interesting, you don't listen and the more you don't listen and you get away with not listening the worse the situation becomes.. And I'm not really interested in what they're saying anyway, and there's no fun in what they're saying, so I've just stopped working. And that's my own fault...but it hasn't helped ... with them catching my attention...

(Year 11, line 169.)

Later during interview she raised the issue of her confidence:

Trouble is, a lot of my confidence has gone, for science now, [I] just don't care anymore..I've lost so much knowledge that I could have had..I wouldn't be surprised if I went into the exam, sat there, wrote my name on the paper and kept turning over the pages, until at the end, when we had to put our pens down. I honestly wouldn't be surprised if I did that.

(Year 11, line 240.)

She stated that she would have dropped science altogether had she been given the opportunity. She was eventually moved to a Double Award science group. She felt that she should have moved groups earlier but her teachers had not been aware of her difficulties.

...my results show me exactly what I've known for months, and been telling the teachers, but it just took until that time, for them to listen to me. And that annoyed me a bit, because I told the teachers before, I'd said, I'm not doing as well as you think I'm doing. I'm not understanding what you think I'm understanding. And I think it seriously needs to be thought about moving down. And they just sort of shrugged it off and then it wasn't until they came out, on paper, in their faces, from the mocks, that they actually did anything about it.

(Year 11, line 347)

She felt that science would have been better with the same teacher, rather than three different teachers and that smaller classes would have enabled her to receive a better level of teacher support to overcome her difficulties. *Once more she stated that teachers were not assessing individual levels of understanding and that she was past trying.*

No I didn't really answer any questions or anything, so don't know why they thought I was understanding...they ask a question and one person answers it, that's it the whole class know it.
(Year 11, line 351.)

She achieved a CC grade for Double Award Science at GCSE. She left school and completed a beauty therapy NVQ 2 and A level drama at a local FE college.

7.5 Stephen

Stephen had high self-esteem as a science learner and was very confident in his ability to be successful in school science during Key Stage 3. In Year 7 he responded that he was very good at many aspects of science including practical work. He considered that practical work was more fun than other work and he did not worry about it going wrong, as he may have done with his written work. He was an active participant in discussions because he enjoyed sharing what he understood and could pick up information from others in this way. Stephen continued to be enthusiastic about science throughout Year 8. In Year 9 he still felt positive about the subject although he was beginning to feel that he was less good at aspects of science linked to abstract thinking such as explaining findings that he considered to be more demanding. In Year 9 he would have liked more freedom in science to do experiments where he did not know the outcome beforehand. He said that doing experiments with unpredictable results was better because he could write down what he observed and think through problems and solutions independently. Stephen, like other pupils, enjoyed learning more when he had autonomy and was given more responsibility for his own learning. He stated that he did not have the opportunity to plan investigations often enough, although he realised there was not enough time to complete all of the work and do 'real' rather than prescribed investigative work. He said there was far too much copying from the board and from books and he had become disillusioned with school science. Stephen had already begun to realise there were changes in ways of working during Key Stage 3. He made many suggestions about how to improve school science

lessons. He stated there was not enough time to discuss results or to present findings to the class and he would have liked more positive feedback in his book. Stephen, like Natasha and Beverley, suggested there was a lack of support at an individual level and that his teacher should have been offering more guidance on how he could improve his work in the future. He found science very boring when his lessons were in a classroom rather than in a laboratory because he could not do practical work. He would have preferred the freedom to use classroom time to do some independent study on aspects of the science curriculum that interested him. He preferred physical science topics to biological science topics in Year 8 and biology more than physics and chemistry in Year 9. Stephen achieved a Level 6 in his science SAT.

At Key Stage 4 Stephen studied three separate sciences, he expected to achieve on average a grade C or D in each science subject. He wanted to be successful at GCSE level so he would have better options in his future work. He felt that studying separate sciences would lead to more qualifications and maybe a job as an engineer or a mechanic in a car racing team. He also wanted to do well for his parents. He had support from his parents for whatever he wanted to do and felt that if he attained high grades his parents would be very pleased. He was in the top science group, where all people thought they were very good at science and like Natasha he found this a motivating factor.

At the beginning of Year 10 Stephen indicated that he was confident in all three sciences and felt that he had a good understanding of what was expected of him. He was beginning to feel apprehensive about chemistry because there were lots of equations to remember and he continued to have difficulty with these. He felt more confident in biology but unsure about physics. He commented about his Year 10 classes that they had not been given the opportunity to revise many aspects of physics and chemistry. When they were balancing equations he felt there was not enough work on it and he needed more practice at them. He found chemistry hard but thought he was beginning to understand equations, and he felt that he had worked through his previous difficulties. Here Stephen was raising issues about time and difficulties with conceptual understanding, although he believed that he could complete equations well, his later reports did not confirm this. Stephen found the coursework/homework in science had all been hard but not impossible. In biology he would have liked more clarification about the coursework such as when to do it and what

exactly was expected. This contrasts with Natasha's experience and indicates that while pupils value autonomy they also need parameters within which to function autonomously. Stephen was unclear about the learning goals and assessment criteria for his science. Stephen was aware that he needed further teacher support at this level.

Stephen said he realised that he had difficulties sometimes with understanding and he needed to go over his work (but he rarely did). In science he felt that he continued to understand the content quite well indicating that his self-esteem as a science learner was not affected. He stated that he was trying hard most of the time, but he felt that he had not fulfilled his potential in chemistry. He was achieving good marks sometimes but usually completed coursework late. He found physics accessible except equations and the associated maths, which he found difficult. He continued to find chemistry, particularly bonding, difficult.

...in physics, like you're working with like a rock falling off a cliff - and I can like visualise that. But if I'm working with atoms in chemistry, I've never seen an atom, so you know, there's like a blob on the board with little circles around it.
(Year 11, line 128.)

I find like the maths side of it difficult. Because I'm not very good at maths... So, the maths was harder for me, like equations and things, and that was one of the big problems ...
(Year 11, line 52.)

I think I'd have managed ...to do like triple science on biology, maybe triple on physics, but dual on chemistry. Because I can't do chemistry at all. Got no hope of ever doing that. But physics I'm all right at - I think I'm pretty good at biology.
(Year 11, line 60.)

He considered that his mock results were mediocre: he achieved a C in physics, an E in chemistry and a D in biology. He thought that he could have achieved better if he had taken his mock exams more seriously:

... the mocks don't mean anything. And then found out that they did, and if they're too crap then you know you're not going to do anything this year. Found out the hard way.
(Year 11, line 196.)

They [the teachers] always said they [mocks] were serious, but you hear from everyone else... forget your mocks, just wait until the real thing, and stuff like that ... I never revised for my mocks.
(Year 11, line 200.)

...because I thought I could do better in some subjects, but I wasn't particularly chuffed with any other results really. It's just like, "Oh - wow".
(Year 11, line 206.)

These comments suggest that Stephen was still not focused on his work. In his view his teachers should have been more explicit about the importance of mock examinations. In science he found the coursework challenging because it was in addition to having to do lots of homework and he found meeting deadlines very hard. He felt that the science coursework was valuable to him, although in his view:

... with science, you can do the course-work, and then not actually know what it means afterwards.
(Year 11, line 140.)

He had three new and different teachers for science, and he felt that getting to know three new teachers was hard although he had mostly good relationships with his teachers and thought they were fair and helpful.

In Year 11 Stephen continued to feel quite confident in all subjects, however he was moved from separate sciences to double award science.

It's got easier, since I was dropped down, but I don't know if that's just because I've covered a lot of the work in triple...
(Year 11, line 46.)

He suggested science was one of the best and most interesting subjects to study at school because he felt that he could find out about things. He expected a grade A/B in Double Award science. Stephen considered that his school science had been a good experience:

I think it's been pretty good. I've learned more in the past like two years, than I did in the rest of my school.
(Year 11, line 6.)

His relationships with teachers was good in all subjects this year:

...now they understand that we're under a lot of strain, and that they have to like 'befriend' us instead of like, rip our heads off...
(Year 11, line 160.)

He suggested that they were all supportive and all gave up their own time to help him proceed to higher grades commenting: *'My science teachers have all been great.'*

Stephen recognised that he struggled with the more abstract aspects of science and in his view science would have been better if the 'basics' had been introduced earlier and then he would have found it easier to work up to more abstract ideas:

...like we are made out of atoms. Like right at the beginning...then work up to "oh the atoms have got to meet first" and stuff like that ... from, year seven, it seems to me we were just learning about fish, and the tadpole cycle. And then when we got to year nine, it was like, right, you're made up out of atoms, and you've got energy shells, and your $NA+I=V$ over R . It was like - woah. So if they like built it up over the years, I think it would like sink in a bit easier and make everything ... make the world a better place.

(Year 11, line 214.)

Stephen was not very clear about what he was going to do after year 11. He had a lot of ideas but little focus and lack of personal direction. He felt that science was important because it was good for life and for qualifications as well as being 'core in today's modern world.'

... one of the qualifications you need, really. Like maths...

(Year 11, line 281.)

Next year he planned to study A level geography and PE. He suggested that he might do a GNVQ in manufacturing or a Modern Apprenticeship:

... I want to either do something to do with cars, or I want to do something with sport. Or be like, a physio. And I reckon that I'll probably need like, biology 'A' level, wouldn't I?

(Year 11, line 256.)

He would not have dropped science given the option. He achieved a DD grade in Double Award science and went to a local Further Education College to study music.

7.6 Alan

Alan had a positive self-esteem as a science learner throughout Key Stage 3. In Year 7 Alan found investigations exciting but he would have liked to do more 'real' investigations, for example 'forensic type' testing on coloured inks as opposed to using laboratory chemicals. This reflected a common concern expressed by pupils that science should be a problem solving experience rather than one of following instructions and that scientific problems should relate and have relevance to their understanding of science in the world. In Year 8 Alan felt more comfortable when asking his teacher for help suggesting that he felt more relaxed and confident in science. In Year 8 he liked practical work and he would have preferred to be given basic information, and practical equipment and a set amount of time to carry out a practical. This suggested that like other pupils he wanted more autonomy in his learning and opportunities to take more responsibility for his learning. He found science exciting and would have liked to engage with science

challenges to create novel applications. He found science lessons easy when the content was repeated. This indicated that although Alan was interested in the subject he felt that the work was perhaps not as challenging as it could have been. *He liked working in groups better than on his own because he liked sharing his ideas with friends.*

In Year 9 he felt that he would do very well in science and he considered that he was very good at it. His teacher agreed that he was good at science. Alan felt he was good at practical work in chemistry and he achieved good results; by good results he meant he got them 'right'. He stated that he liked practical work best because he still did not like writing and he said that planning experiments was acceptable to him in moderation. He found bookwork easy but boring and felt that there was too much of it. He did not like biology much because he could not observe what happened as he could in chemistry, also he did not like remembering the parts of the body because he was not interested in it. He would have dropped biology at the end of the year given the option. At this stage Alan was showing some signs of losing interest in some aspects of science. Implicit in his comments were that some aspects, or ways of working, in science lessons were problematic either because they did not enable him to be active in the learning process or because the topic lacked interest and relevance for him. Alan preferred physical science to biological science topics in Year 7, 8 and 9. He achieved a Level 6 in his science SAT.

At GCSE level he studied separate sciences and enjoyed studying subjects more intensely and getting more deeply involved with the content. This implied that he was beginning to understand science and make connections in his learning. He expected to achieve good marks in all science subjects including biology but expected chemistry to be his best achievement.

He had good relationships with his teachers and believed that two of them (physics and chemistry) were good. He felt that his biology teacher did not appear to be bothered what he achieved, and these perceived low expectations possibly had an effect on Alan's level of interest. He felt intrinsically motivated to learn and be successful by the prospect of getting a good job, he wanted to be successful in all subjects but

especially science and maths. He thought that he might do chemistry A level if he did well at it at GCSE, he also wanted to study maths and food at advanced level.

By the end of Year 11 he felt that he had tried hard in science and he understood chemistry well and better than physics and biology. He found biology difficult throughout the two-year course and Year 11 physics very difficult. He had not enjoyed and did not feel that he understood any aspects of biology, he was not interested in cells and plants consequently he was not working hard in biology. In biology and physics he felt that the coursework was too late in the course and they were not explained well enough. This is a concern shared by other pupils that can be related to the lack of transparency of the learning goals and assessment procedures in science. He felt that the science coursework had not really helped his understanding much. He said of his biology teacher:

...because once I went up to see her about some coursework, because she's even lost like half my coursework and had to do it again. And (as) she walked past me and I said "Miss" and she just walked past me. She ignored me and she saw me. It's like - see it's that kind of attitude.
(Year 11, line 377.)

In spite of these perceived difficulties and some lack of confidence Alan still believed he would achieve good passes in all three science subjects. He was doing better now than he expected to do at the start of his GCSE course. He enjoyed the practical work most throughout his science courses although he did not feel they had done as much practical work as he had expected to at this level. He mentioned earlier that his level of interest increased and he worked harder if he was doing good, fun practical work.

Like Zahadil, Alan did not consider that relationships with teachers should affect his learning but he thought that they did. He felt that he had got on well with his chemistry teacher but:

...I don't get on with my other two though. They don't listen to you and don't explain things clearly. (Year 11, Q. 7.)

He suggested that effective learning depended on teaching style and sometimes even though he could not get on with some people they could still be good teachers. He felt he was doing well despite two of his

teachers. Here Alan was suggesting that for him learning was independent of the teacher-pupil relationship and he felt that the teaching style in his GCSE courses could have been improved:

... these two years it's just been like copying off the board. We've done like, a few practicals, but not many. Working out of the book is boring.
(Year 11, line 430.)

He felt that there had been too much teacher talking whereas all that was needed was:

...a bit of talking at the beginning to explain what you're doing, but only like for five minutes, ten minutes, and then you do your practical. But also, like the talking bit has to be pretty fun.
(Year 11, line 440.)

Yes, it's like Mr. X [Key Stage 3 teacher] always used to like, make everything fun, how he explained it.
(Year 11 line 444.)

Alan made two distinctive points. That the teacher talk should be more focused to enable the pupils to have more time to complete the experiments and teacher explanations should be more accessible. He thought class discussion was reasonable but that there were some difficulties with it:

Yes, because usually everyone just like .. puts their hand up. Or just shouts it out. Some people don't get the chance to do things like, say the answer.
(Year 11, line 457.)

Here Alan was alluding to the importance of all pupils having a voice and a right to be listened to in the learning situation. When pupils did not feel that their ideas were valued it could lead to a decrease in motivation, and interest and this would impact on the quality of their learning. He felt that group work was sometimes better than whole class discussion because:

...you could... discuss what you're doing in groups between you. Not many people do but, like but .. if you .. someone talking at the front, you can't discuss between you. But then you only just end up talking about nothing ...
(Year 11, line 461.)

In his mock examinations he achieved a C grade in physics and biology and a B grade in chemistry. These reflected his own and teacher expectations in Year 10 and 11. He considered studying chemistry at A level but his final grade was not high enough for him to be able to do so. He achieved grade C in biology and chemistry and grade D in physics at GCSE level and went on to study maths and geography A level at school. He eventually studied geography at a local university.

7.7 Hayley

Hayley had high self-esteem as a science learner during Key Stage 3. In Year 7 she felt she was good at many aspects of science. In Year 8 she considered she was good at research projects, doing practical work and explaining her findings. She liked practical work because she felt that it was good to find things out for herself and it was fun. She said that writing was a worthwhile task as long as she understood the work. She liked group work because she felt that she could share ideas and she did not mind who she worked with. There seems to be recognition among many pupils that having opportunities to share ideas is beneficial to learning.

In Year 9 she felt she was very good at explaining her findings, practical work, writing up her work and presenting information. Towards the end of Year 9 she said she was losing interest in physics, as she did not feel it was relevant to her. Hayley particularly enjoyed the project-based work in chemistry as this had an element of pupil choice of experiments and continued over a five-week period. Hayley enjoyed it as it allowed her to work independently and creatively. Hayley disliked the amount of bookwork and teacher talk in Year 9. She also disliked planning experiments, especially formal science investigations (Sc 1). She did not enjoy science homework, as she would have preferred to work independently out of school rather than be teacher directed, as she felt she could do much better that way. Hayley enjoyed physical and biological topics equally in Year 7 and 8 but in Year 9 she enjoyed chemistry and biology because they were more relevant to her. She considered that physics was difficult and irrelevant. This view is consistent with that of Natasha's who also found that a lack of relevance limited her access to physics that in turn made it more difficult and less interesting. Three boys, Chris and Stephen in chemistry and Alan in biology tended to associate a lack of relevance with boredom but they too struggled to access science that they found had little meaning for them. The lack of real life contexts and the difficulties associated with school science were beginning to effect Hayley's motivation and interest in, and enjoyment of, school science. She felt nothing was really easy in science. She achieved a Level 6 in science SAT.

In Year 10 Hayley studied separate sciences. But even though she achieved a SAT level 6 in science she felt apprehensive about all three science subjects at this level in contrast to Alan. She found that Year 10 was very different from Year 9 and felt that pupils could have been better prepared for starting Year 10 by knowing more about what was to be expected of them. This is an observation made by other pupils, for example Stephen and Chris. The lack of transparency of learning goals and of assessment requirements means that pupils' make inappropriate assumptions about what kind of work and level of understanding is required of them at GCSE. Even so, Hayley expected to do well in her science courses. When she started Year 10 she expected three A-C grades in science, her teacher expected she could achieve an A in physics and a C in chemistry and biology. But even though her estimated grades were matched by her teachers' grades she attained 37% in biology (grade C/D), 26% in chemistry (grade D/E) and 60% in physics (grade B/C) in her Year 10 examinations. She was unhappy with her results. She found studying three sciences hard and she felt that the work needed to be explained more thoroughly and repeated, particularly in physics. She said that more work with past papers would have improved her test scores. She stated that there was not enough time to absorb everything and her chemistry teacher talked too much. She thought all of her teachers should have spent more time clarifying explanations after pupils had completed their written and practical work. Hayley was very clear that there was far too little time for her to understand and learn all of the content in her science courses. Natasha, Alan and Beverley also commented that studying three sciences was pressured. This pressure got in the way of them being active in the learning process and having control over their learning and limited their enjoyment, and in some cases their achievements, in science.

In Year 11 chemistry, she found that the teacher's explanations were poor and *'he simply wandered around the subject'*. She expected her teacher to be more focused and clear and felt poor explanations were the major cause of her lack of understanding. Several pupils commented on the problem of poor teacher explanations and how this affected their learning. This appeared to be a particular problem for some pupils in chemistry and physics (Chris, Sian, Beverley, Natasha and Hayley) and a problem for Beverley and Chris in biology. For Hayley the problem she experienced in biology was that she did not find her teacher very supportive and she was not providing Hayley with enough time or interest.

...she [the biology teacher] says that you're being cheeky, and I'm just trying to find out, and yes, I've got to admit, I am cheeky at times, but that's because you just get so frustrated with the teacher not wanting to help me.

(Year 11, lines 103 –108.) (verified by Hayley, June 2000)

And then you get to the stage where you don't want to ask questions, because they make out you're really thick for asking that.

(Year 11, line 119.)

She felt that her biology teacher rushed through the work. In Hayley's view her biology teacher focused her time on only a few pupils. This lack of attention and the feeling of not being valued was also experienced by Alan and identified as a problem for his learning in biology. These factors impacted on Hayley's engagement with her learning. She reported that she was not enjoying science or the coursework much at present and therefore she was not doing much work towards it. This is somewhat similar to Chris' response. She felt that if the coursework content was more relevant and interesting a then she would have been more positive about it.

Hayley felt that both her biology and her physics teachers were patronising and did not value her views and ideas:

I don't know what I find the most hard, but when we're doing these past papers, they always use the one that I can't write a single thing for it. I don't know anything myself. Like, there was a question today, and I could write it in simple form for my common sense of I know what happens, but I don't know why it happens, and I don't know scientifically how it happens, so I wouldn't get all the marks for it, do you know what I mean. I can understand it, what's happened.

(Year 11, line 256.)

...and I can't explain in science why. Because I just haven't got the knowledge - I don't know it at all.

(Year 11, line 258.)

Sometimes she felt that her teacher was suggesting the questions she asked were not scientific enough for this level of study. Her chemistry teacher she found was quite understanding. She considered that her biology and physics teachers' approach did not suit her learning style. (She commented that this was ironic as biology turned out to be her best science grade, Hayley, June 2000).

Hayley's achievements in Year 11 were much improved on her predicted grades except in physics in spite of her perceived relationships with her teachers. Her teacher reports half way through Year 11 were very positive although *there is an indication that Hayley was considered to be failing in terms of effort and that her results were unexpected.*

Biology. She has made good progress in biology. I am pleased with her trial exam score. She is *an able student who has attained this standard without her best effort. I believe that she is capable of getting a higher grade if she puts her mind to it.* Mock: 57.5%; Estimated grade: B

Chemistry. Firstly I have to admit how pleased and surprised I was with her mock result. She should gain greatly in confidence as it indicates that a high grade is within her grasp. It is important that she now continues this encouraging approach in the run up to the main exams. Mock: 60%. Estimated grade: B

Physics. She can achieve a very high grade and her exam result was pleasing. She could do even better however, *if she made more use of lesson time. She can waste time talking although this has improved recently. She now needs to practice answering exam type questions.* Mock: 74%. Estimated grade: B.

The teachers' explanations for Hayley's performance suggest that they do not perceive any problems in Hayley's understanding of the subject this contrasts with Hayley's views. She was really surprised and pleased with her mock examination results, but she continued to question her level of understanding. (verified by Hayley, June 2000). This mismatch between a pupil's achievements and their views of their understanding was also apparent in Natasha's account of her science experiences, particularly in physics.

...but I can't understand how I'm getting those expected grades

I was so surprised with how well I did - If I've got that when I don't seem to understand anything in science, then I wonder what I would've been like if I would have had set teaching so that I could've come out with all 'A's in all of them.
(Year 11, lines 96 and 98.)

... biology, which is the one I'm probably the most interested in, because it's about the body, it's about things... that appeals to me more than chemistry and physics, but that's the one I'm doing the worst in because I really don't know anything... Whereas physics, you're given equations, and I've got the sense to know how to use them, and chemistry... you've got a data book, and so I can look in that and find the answers...
(Year 11, line 100.)

Hayley felt that she could use her 'common sense' to understand science. We discussed what aspects of biology she was having difficulties with:

Biology, honestly everything. I don't think I know a single thing, and biology's my one that I'm coming out with the worst grades. When I would expect they would be the best. But it isn't, because there's no like equations that I can just use, or whatever.

She went on about her difficulties with Physics:

...there's another thing I don't understand, it's that left hand rule thing ... and there's magnets, and which way is the current going, and if you put a rod there it'll turn ... what? Think it's the teacher as well, and also, I do find physics the least interesting, so I try harder in the other two, than physics...because I just don't find electricity and things like that interesting. Forces and .. just don't interest me.

(Year 11, lines 210–216.)

Later in Year 11 she felt that she was completing the majority of her courses successfully but she was worried about her science courses, which she found most difficult. She had tried really hard to counter her lack of interest in and enjoyment of science, especially physics. Extra physics lessons after school, with a different teacher had really helped her. She had not understood the content well and felt extremely unsure about her understanding. She had however begun to see her achievements in science as to do with her level of interest rather than solely her teachers' teaching. She did not see the two as interrelated as Natasha did.

I'm not enjoying science at all at the moment. But it's not totally the teacher's fault. I'm not interested in science myself, anyway, so it's partly me to blame, but I think that if it would have been taught differently, they maybe I would have tried to concentrate more, and found that I did enjoy stuff. Because you don't enjoy things when you can't understand a thing they're saying. Like, if you keep not being able to do things, you just end up not bothering.

(Year 11, line 92.)

Hayley made observations about her science experience and she felt it could have been better if the coursework was spread out over Year 10 and 11, if they had only one teacher for science (not three different people), and if she could have changed her biology and physics teachers. However as Hayley observed in spite of this she continued to achieve well. (verified by Hayley, June 2000)

I've tried a lot harder in other subjects than I have in science, because I've enjoyed them more. But, even though I have tried harder than I've tried in science, I do think that if I were to try a hundred percent from the start, and really realise how soon the GCSE's come up, and how important the whole of year ten and eleven are, then I could be doing better, but, lucky for me, I'm still coming out with good marks anyway. But I just think if I would have tried a bit harder and everything, what I could be coming out with.

(Year 11, line 171.)

Hayley would not have dropped any science given the option, as she wanted to get a good set of GCSE results. She was motivated to get good qualifications to enter the sixth form and ultimately to go to university. Job opportunities would be better in the future if she had a range of good qualifications. It was

important to get good grades, even in subjects she did not think she would necessarily need or enjoy that much, like science. She would also like to please her parents.

Years ago, you didn't have to do science. You could have done more like, I could have done RE and Geography. I wouldn't have bothered with science then.

(Year 11, line 450.)

But, if you're asking if I had my time again, would I still choose these sciences, then yes I would, because I know that science is important.

(Year 11, line 454.)

She was not sure whether science was important to her:

...it's really my common sense to find out about safety issues and how to change a fuse.

(Year 11, line 467.)

She did not want to carry on with science and she did not feel that she needed to understand any more about science. Hayley's achieved grade B in physics and chemistry and grade A in biology

A letter from Hayley received in June 2000 suggested that she really enjoyed reading her account and found some of the things she said amusing. She commented that she felt totally confused and unsure about what to do next year and that as much as she had moaned during her GCSE years (as she had just read) she would love to be back there, as she felt now there were too many decisions to make! She had applied to, and been offered places to study at university but she had also applied for business training schemes with Peugeot, Marconi, etc. She planned to leave her options open, as at present she felt sick of full time education. Her expected A level grades were B for English literature, A/B in psychology and a C in history. She felt very unsure about her grades particularly history but she hoped to attain the expected grades. She eventually studied law at a local university.

7.8 Sian

Sian had a high level of self-esteem with respect to school science during Key Stage 3. In Year 7-9 she was good at practical work as she considered it was more interesting than writing. She was aware that learning for her needed to be an active process i.e. to be positively engaged within the learning process and when

given the opportunity to develop her thinking and write down her ideas, she thought she learned more. She thought that girls could be better at science if they did more work with chemicals:

...most people think that when you go to secondary school that it [science] is going to be brilliant because we're going to be doing loads of work with the Bunsen's, but we don't really.

In Year 8 she found science very exciting particularly when she did not know what was going to happen in her experiments. The unpredictable nature of experiments was a feature that many pupils identified as significant in their learning as it gave them a challenge and a problem to be actively engaged with. In Year 9 she would have liked more time to plan and develop experiments as she felt she would have learned more if the experiments were not so structured. She would have liked more practical work and to have been asked more about her opinions and to have the opportunity to share ideas. Sian disliked all of the copying from boards and books and repetitive work. She found it easy work and but did not feel that she remembered anything if she simply copied the work down. By the end of Year 9 Sian was beginning to observe that some of the science she was learning at school (in physics and chemistry) was not particularly relevant to her. She challenged the relevance of science:

...we are not going to use acids at home.

She also suggested that:

...equations are not exactly useful for jobs...if you have got to learn science you may as well make it interesting.

She still felt some science was important and useful to know, particularly biology, because this enabled her to understand an operation she had had recently.

She enjoyed biological and physical science topics in Year 7 and 8 but in Year 9 preferred biology to physics or chemistry. She achieved Level 5 in science SAT.

In Year 10 Sian expected to achieve a grade C or higher in all of her subjects. Her teacher estimated a B grade for Double Award science at the beginning of her course. Sian had a long-term absence from September 1996 to January 1997. Sian was absent for the Year 10 interview and the data presented here was collated from her pre-interview questionnaire. She felt fairly confident about all of her GCSE subjects

including science but was a little nervous about the final exams and her expected grades. She did not think she was particularly good at science and even though she was working hard she had a low level of self-efficacy. *In the Double Award science course she felt she could work at her own pace and there was not a rush to get everything done, as there appeared to be in separate science.* From her studies she hoped to develop her knowledge and understanding of science. She was concerned about the work in chemistry as she found it difficult to remember formulae. Sian's difficulties with this had started in Year 8, these difficulties did not appear to have been addressed.

She felt that because the Double Award science classes were large, teachers were constrained in their ability to help individual pupils. Sian's view, in contrast to other pupils like Beverley, was that insufficient time rather than her teacher's lack of awareness that support was required was the problem. She expected her science coursework and subsequent qualification would indirectly provide her with better choices in terms of her future employment. *She felt coursework in science involved a lot of repetition, but this helped her to remember information.* Although she considered the pace in double science to be more realistic and less pressured compared with separate sciences she felt that pupils had to work a lot faster than in other subjects so they could cover more work, and she found it difficult to keep up with the volume of work. All of her teachers were helpful and supportive. She observed that if she was not successful in science she would not be too bothered as *it was not her favourite subject, but she would try to be successful in science.* Her parents were very supportive and wanted her to succeed and she was personally motivated to do well and did not like to fail. She wanted to get the best opportunities in her life and would work hard to achieve them.

In Year 11 Sian felt quite confident in all of her subjects and that she was completing her courses to the best of her ability. She was doing well in maths, RE and English, but science was her main concern although she felt she would do reasonably well. Her teacher estimated grades at the beginning and end of Year 11 was a B grade, Sian estimated she could achieve a C grade. Her views on science had not changed much:

I still don't like it. I just don't understand it. ... I really enjoy biology and I'm better at biology than I was before. But the physics and chemistry, I haven't got a clue. And my GCSE's... should be all right...But it's not enjoyable.

(Year 11, line 12.)

For Sian like other pupils particularly Hayley, there was a strong relationship between understanding and enjoyment. Without understanding Sian could not evaluate herself positively and this had an impact on her self-esteem as a learner.

... science I think is going to be one of the main worries, but I should be all right with that, if I revise and go through it all again... the amount of it ... it puts me off a bit.

(Year 11, line 53.)

Her mock examination results in Year 11 were quite good (all around a C grade).

And my GCSE's. They should be alright, because my mocks were quite good which I was surprised about.

(Year 11, line 12.)

But she did feel that she needed to concentrate more:

...because it's my GCSE's, and I know it's important to get like a good grade in science ... especially because I didn't really get what I was hoping for [in English]... So I'd like to concentrate a lot more and sort of get down to it - but I feel at the moment that we're not really doing that much revising that we need to do in the lesson. It's just like - turn to this page and answer the questions that they mention. And we've done all right, really, but I suppose we're supposed to be doing it at home as well, which I am, but ... I've got to knuckle down, I suppose, and get on with it a lot more than in the other years.

(Year 11, line 8.)

For Double award science at this school pupils have two teachers but it is common practice for only one report to be written per subject. Sian's teacher reported in Y11:

I have been very pleased with the quiet and determined way that Sian has got on with her work this year. Her mock result (61%) was very encouraging and I am sure that she will improve on this in the summer. Her chemistry mark let her down and this is the area that she should particularly concentrate on.

Although Sian enjoyed biology, she did better than expected in her physics than biology mock exam. She explained that she had 'not got a clue' in physics and chemistry, but she worked hard for physics and she was really shocked with her physics mock examination as she got the highest mark in her class. This is indicative of Sian's lack of confidence in her own ability to achieve without understanding, a similar view to that expressed by Hayley. Her chemistry mock was low because of her difficulties with equations, bonding and names of chemicals, although she liked doing chemical reactions. She was concerned about

when she was going to use this information, a concern she had expressed since Year 8 and she raised the question of relevance.

...half the stuff you learn as well and you're thinking - when am I going to use this? ...when is it going to be relevant to you? ...we did about aluminium, the other day - the making of aluminium. ...when am I going to need to know how to make aluminium? ... you [the interviewer] might want to!

(Year 11, line 20.)

I don't see the relevance of it but... So it's really confusing to me.

(Year 11, line 39.)

... you're not going to see an atom bond, are you ... so what's the point?

(Year 11, line 86.)

She enjoyed all of the practical work she did in Years 10 and 11 because it was not simply teachers doing demonstrations. She enjoyed the course work. Unlike other pupils, she felt that two of her pieces of coursework in science had really helped her understanding.

... my best one in science would be the rates of reaction, catalyst one. Because we were just given a sheet ... like a sentence ...and if you read the sentence properly and did exactly what it said in the sentence, then you'd do it. And I ... think I got nearly full marks for it - and that one was really good.

(Year 11, line 130.)

Earlier Sian had suggested that she enjoyed planning her own experiments and working independently.

With the pressure of assessed coursework Sian seemed content to achieve high marks following teacher directed practical work. She thought she did well in her science coursework because:

... we weren't allowed to take them home. We had to do them in the lesson...so because we had the whole lesson, we had the help there if we needed it, then we got on with it...and we could do it.

(Year 11, lines 154, 156.)

Sian felt confident completing this coursework as her peers and teachers supported her. She had two views on coursework, one was that it helped her understanding and secondly that if she produced good coursework it would improve her overall grade. Her relationship with her teachers was fairly good, with a lot of support when she was absent from school and on her return to school. She felt her physics teacher expected too much too soon after her illness, but her biology and chemistry teacher was good and explained things well. Her relationship with her teachers depended both on their personality and the way they worked. She would have liked less teacher changeover (her physics teacher left during half way through Year 11 and she had two teachers that left earlier to go on maternity leave) through her GCSE course:

I think from the start...I had a change of teachers quite a lot... it's like change over then you'd have to start fresh with that teacher again to get used to them, and that was a big problem ...
(Year 11, line 238.)

She would have liked all of her teachers to adopt what she considered to be 'good' teaching methods whereby there was a discussion followed by questions and answers to find out what she had learned.

...and Miss X got quite a good method...she starts on a topic, and then she goes all the way through it ... at the end, when you're packing up, she fires questions at you... it's much easier to do that way, instead of writing it all down.
(Year 11, line 248.)

Sian indicated here that this teacher aided her learning by making her reflect on what she had learned during the lesson. She also felt it was important to recap work done in the following lesson.

She would liked to have done more experiments herself rather than using books and video tapes because in her view she learned more by making mistakes and having the opportunity to work out why. This is a very insightful view of the learning process through the resolution of 'fruitful errors'. This is what that Bruner (1996) argues for when he suggests that there should be opportunities for discourse that permits the individual to discover how or why things did not work out as planned. The support offered to the pupil in this respect can have a powerful effect on pupil self-esteem.

Sian would have liked to have more time to study her science.

Yes, [doing practical work] you make your own mistakes, and then you know not what to do next time, and how to improve it, and .. but I just don't think in year ten and eleven they've got the time to do it in... I find that difficult.
(Year 11, line 258.)

She would have liked to have the opportunity to drop chemistry and physics because she did not see the relevance of these subjects for herself; she could then have concentrated more on biology. She achieved a DD grade at Double Award level.

She did not consider science important as a subject in itself but thought that the qualification was important because it looked good on job or course application forms. She added that school science was only important if it was relevant to the occupation being taken up. As she wanted to study Health and Social

Care GNVQ Advanced in the sixth form and to become a social worker, she did not think science would be particularly useful to her.

A letter from Sian confirming the accuracy of her story June 2000 indicated that she was planning to take a year out to continue working at the care home where she had been working part-time for three years. She expected to go on to social work or to explore mental health as she had had recent experience as a member of a steering group for a new project of MIND, the mental health charity.

7.9 Stan

Stan had very positive self-esteem in school science during Key Stage 3. In Year 7 and 8 he felt that he was very good at most science activities. But during Year 8 Stan found it boring not being able to develop relevant investigations. He suggested that science would have been better if pupils could have made up real investigations; and that these would have more possibilities for learning and making 'fruitful errors' as noted by Sian. He liked group work if all the members had a definite task because he felt that sometimes when he worked in groups there was a lot of time wasting.

In Year 9 he said that experiments were more fun and interesting than other work in science especially when they had to make up their own experiments, but he was more interested in experimental outcomes. He suggested that when the work was more interesting he would be more likely to learn. He considered that group work was good when there was lots of talking and sharing of ideas. He found the work was better for him this year with lots of practical work in biology and chemistry and writing up for homework. He felt that it was important to write up experiments because when he looked back at them he could make sense of experimental outcomes and he found this exciting. He felt that practicing old examination papers was a good activity that helped him learn and indicated gaps in his science knowledge and understanding. His enthusiasm for science decreased towards the end of during Year 9 because there was less practical activity and the content in physics was in his view becoming far more conceptually demanding.

Years 7 and 8 I was really interested in science, and then I sort of lost interest with it in Year 9.
(Year 11, line 13.)

He achieved a Level 5 in science SAT. He wanted to study A level history, English, graphics and maths and go on to do a law degree at university.

At Key Stage 4 Stan was studying Double Award science and felt confident he would achieve grade BB, but would be happy with a CC. He thought that a good grade in science would provide him with a better range of job opportunities. He was a bit apprehensive about his GCSE science course because he did not know what the science examinations would be like. He felt that he should do lots of revision in preparation for examinations. *He felt that the practical work was much better in Year 10 but did not enjoy other aspects of it.* For example he would have liked less copying off the board in physics and would have liked the lesson to be interspersed with explanations and experiments. He did not understand things if he was just copying information from the board. He would have liked to do more free style/ creative writing using key words given by the teacher. He considered that he was good at chemistry because he liked it. He understood most of the science content, apart from some physics. *He thought that though he was doing well in science he needed to focus more and work harder at home to learn the work thoroughly.* Overall he felt that he was achieving reasonably. His teacher estimated grade was C in Year 10 and 11.

He was pleased to have different science teachers from his KS3 teacher. He felt that he had good relationships with all of his teachers and found them helpful and supportive and explained things well providing lots of examples. In Year 11 he began to enjoy science more and he estimated that he would get a science grade C/D:

I didn't really like science in Year 10 so much, but I started to like it in Year 11 though. It's just become more interesting - I think I'm more ambitious in myself, in science now. (Year 11, line 7.)

I think you have to make yourself enjoy it...I think if you don't really naturally enjoy it, it's not worth doing it ... because you just lose interest in the end.
(Year 11, line 99.)

In chemistry he felt the experiments were interesting:

...it's just I find it interesting with...I like doing experiments quite a bit, and seeing chemical reactions...I'm quite interested in that kind of stuff.
(Year 11, line 185.)

In physics he found that it was hard to work out formulae for calculations and he felt that teacher explanations continued to be poor. He found that nearly all of the physics had been difficult:

I'm not naturally good at physics, so like, when all of these like equations come up, and work out the force of whatever... I think forces and motion is probably the one I've found hardest...I hated that so much.

(Year 11, line 158.)

He felt that his relationship with his science teachers was satisfactory but he felt that sometimes some of his science teachers lacked control this year:

Our science teachers could be doing with a bit of like, you know, showing how to... deal with kids. Because at the moment they are so weak ...they're not, like, strict enough. (Year 11, line 313.)

He suggested that many pupils were rude to his teachers:

...you get swearing in the class and everything. People will go to the teacher and they'll explain something, not properly, and they'll just go ...shut up, now... and they [the teachers] just don't say anything at all.

(Year 11, line 315.)

He felt that if his teachers had been stricter he would have been able to work harder. This was a view that was shared by two other boys, Zahadil and Chris. Stan continued to be motivated and felt confident of his success following his mock examinations in Year 11.

I was pretty pleased with my outcome in the mock exams. I thought I might just be able to get a C in my science subjects. I missed a 'C' by one per cent.

(Year 11, line 317.)

Stan was of the opinion that it would have been better if he could have chosen 2 out of the 3 subject disciplines in science.

I think for the exams - you know you get single science, dual science and triple science, I think, you should be allowed to choose the two science ...I think you should be able to choose the two subjects in science that you might be the strongest in. And the same for single science. If you're doing single science, you should either choose biology, chemistry or physics.

(Year 11, line 360.)

He suggested that it would have been useful to look at exam papers more often and that would have helped with his revision. He also felt that his teachers should have worked more diagnostically and then they would have been able to help the pupils concentrate specifically on their areas of weakness. He felt that science was important:

...because it can take me on to different things ... it's such an important thing to know.
(Year 11, line 482.)

Along with English and maths he noted that they:

...are the ones that are going to get you through...
(Year 11, line 486.)

Stan achieved a CC grade in Double Award science at the foundation level the top grade possible, a higher achievement level than Beverley, Sian and Stephen attained. He went on to study A levels at a local FE college.

7.10 Samantha

In contrast to all of the other cases Samantha had a low self-esteem in science in Year 7. In Year 8 she did not think she was very good at many aspects of science although she thought she was good at doing experiments and found them easy and enjoyable. In Year 8 she would have liked the experiments to be more exciting, for example to do more work with fireworks. She would also have liked shorter topics more trips out to find out more about 'real sciency things', for example going to a local woodland park. She would also have liked more time to design experiments and make things. She felt that there was insufficient time because her teacher talked too much. She did not think science was exciting and felt that writing up was very boring and difficult.

In Year 9 she responded to the majority of survey questions about her view of her performance in science activities in the 'not very good' or 'poor at' categories, although she continued to think she was good at practical work and writing. Samantha liked doing practical work because she felt that it was more fun than writing. She preferred biological science to physical science topics. She achieved Level 4 in science SAT, which is considered to be below average for the age range and was the lowest level attained by the case study pupils.

Samantha like Stan began to study Double Award science at foundation level in Key Stage 4 and her teacher estimated she could achieve EE grades. Samantha responded on her pre interview sheet that she

was confident in all of her subjects at start of her GCSE courses, including science. During interview later in Year 10 she explained that she was not confident in Double Award science; she said it was mainly because *her teacher wrote on the board and the class had to copy the work. This style of teaching was not helping Samantha develop her science understanding and therefore her confidence in the subject.*

She liked chemistry because there were lots of experiments but found physics and biology boring because there were fewer experiments and therefore more writing. She felt the topics were rushed and there was a lack of continuity between lessons. She did not think she was going to do very well in science and expected an E/F grade at foundation level although she would have liked to achieve a higher grade. Overall she felt she understood chemistry and biology, but she found physics hard.

She had good relationships with all of her teachers and because she worked hard she felt her teachers were fair to her. *She suggested her parents wanted her to be successful so she would not have to rely on other people and this motivated her. She thought school science would be very useful to her in the future.*

She enjoyed the biology topics in the course because they were more interesting to her than physics or chemistry topics. She felt the science of the human body was important:

...biology, because that's like, human body and drugs.. it's important.
(Year 11, line 479.)

She found chemistry and equations meaningless and she continued not to like the volume of written work.

She did not like science in Year 11 because of one of her teachers was:

... not strict at all, she doesn't even listen to us. It's like we're not there. But the other teacher, you can get on with her, but she's strict as well.
(Year 11, line 356.)

...because one just makes you copy things off the board all the time, and the other one helps you with it. She talks you through it, and that.
(Year 11, line 47.)

With the teacher she liked, she felt that learned a lot because the teacher talked with the pupils and explained concepts. She thought that her other teacher was not particularly interested in what she had to say so she decided not to work. She felt that her mock exams were good practice but she was disappointed

with her results in some subjects other than science and not really disappointed with her science results. She was glad to be finishing her science studies. She achieved an F grade in Single Award science. She had thought about doing A level chemistry but this was a completely unrealistic expectation on her part and says something about her awareness of the relationship between levels/tiers at GCSE and A level requirements. Eventually she wanted to study GNVQ Health and Social Care in the sixth form, as well as a single GNVQ in IT.

7.11 Discussion

In Chapter 6 I argued a need to move away from a concern with attitudes to consider influences in the learning environment that mediated pupils' learning in science and their view of themselves in relation to it. I argued that learners' self-esteem was an important focus for understanding how pupils became positioned in science, the consequences for their learning and attainment in the subject and how they come to value it. In trying to understand what the accounts tell me I apply Bruner's concept of selfhood, which was discussed in chapter 6. Bruner defined two aspects of selfhood, the first being agency. Several of the influences referred to by pupils can be understood as experiences that limit their agency in the learning process i.e. their capacity for both initiating and completing actions. The second aspect of selfhood is evaluation, this refers to pupils' views of their efficacy in achieving what they were asked to do and or what they themselves hoped to do. Many of the pupils' experiences are concerned with their evaluations of what limits their learning in science and their responses to this. I argue that these concepts are useful tools for analysing the accounts and for identifying those pupils who in spite of their achievements in science turn away from it or aspects of it and what is implicated in their decisions. It also allows me to identify those pupils who are unable to address the dilemmas they experience in their science learning and whose self-esteem is therefore lowered with consequences for their achievements. These pupils are turned away from science or aspects of it by their teachers' judgements of their efficacy, judgements that the pupils accept in the same way they accept their failure as science learners.

The following summary of unique perspectives illustrate the way that the individuals responded to the various influences on their science experience and resolved the dilemmas that emerged for them. Clearly *the accounts are limited but they nevertheless provide important illumination of a complex dynamic.* Zahadil, for example, was intrinsically motivated to value science. He had a long-term ambition to become a professional in the scientific community and this was reinforced in the value accorded to science by his family. Zahadil did experience science as difficult and became distanced, in particular from physics. He attributed this to the pedagogy rather than the subject. Zahadil's response to his loss of interest was to work even harder *to make sense of his science. At no point is Zahadil critical of the subject, nor does he attribute his lack of interest to his own self-efficacy.* Indeed his response to work harder against the odds is evidence of his belief in his self-efficacy. Zahadil's success in science was constrained by his school experience both in terms of the nature of the subject at Key Stage 4 and by the teaching approaches that undermined his agency as a learner. However Zahadil remained within science, though gave up physics, the subject he least enjoyed.

Natasha, like Zahadil, was intrinsically motivated to pursue science for her career aspirations. She was a high-achieving girl who took a critical reflective stance to her learning. She was very aware of what constrained her efficacy as a learner and associated that with both teaching approaches and the nature of school science. She was very aware when things did not make sense and she associated her lack of interest in the subject with the absence of relevance and meaning in her science experiences. She also recognised the approaches to teaching that limited her ability to engage and develop understanding. For Natasha her understanding of what made her an effective learner was the most sophisticated of all the cases. In biology, although she was critical of the teaching, she was able to make sense of and establish purpose in the tasks. Her experience of chemistry appears not to have been something she spoke out about. Her difficulties with it appear related mainly to the fast pace of the lessons and the extent of the content that limited her ability to really develop her understanding. In physics all the influences that undermined Natasha's learning were experienced and identified as barriers to her learning. First, like the other subjects, the pace was too fast and the content too extensive. Second, the teaching approaches limited her ability to actively engage and gain understanding. In relation to the second barrier two other influences were identified by Natasha that

she was unable to resolve. The first influence was her relationship with and views of her teacher. Natasha was aware she had difficulties understanding but knew that this was not because she lacked the potential to understand. *She evaluated her learning and knew she was effective. Consequently, faced with her teacher's behaviour that attributed the problem of her learning to Natasha, Natasha lost her trust and relationship with the teacher.* The second influence was the representation of physics as a content that was abstract and lacked functionality and relevance to life. Natasha worked hard to make sense of the content but as she had no such problems with any of her other subjects she became critical of the subject itself. *Natasha achieved well in her science but rejected physics and rejected a future educational experience that had the same qualities of fast pace and overloaded content as not for her.* Science up to a point lost Natasha.

Chris was a very different learner to Zahadil and Natasha. He had little home support for learning so was reliant on school to form and maintain his self-esteem. He had no long-term aspirations but started his study of science motivated, interested and with potential. For Chris the subject lacked relevance and that limited his interest, but the more influential experiences for Chris related to his teachers' expectations of him and Chris' understanding of, and access to, the processes of assessment that dominated his Key Stage 4 experience. Chris was not aware of the assessment 'game', it was not obvious to him or was not something that was made explicit at home. First and foremost he needed his teachers to recognise his potential and his needs generally as a vulnerable learner in school and then in relation to science. As this did not happen Chris began to experience failure and did not feel supported by his teachers who seemed unaware of his needs. His loss of commitment was reflected in his lack of effort and that impacted on his interest and motivation because he was no longer engaging with the subject. Hence boredom and disaffection became his predominant experience of science. Faced with this, his teachers moved him to what they perceived as the lowest level of science – the single award. For the teachers, they were concerned to match Chris' level of effort with the potential for success in science. His effort would, in their view, only allow success on a narrow science experience. Chris had limited access to science as a consequence and was overtly removed from it. His position in relation to it could therefore only be marginal.

Beverley in common with other pupils had potential in science but by the end of Key Stage 3 she was losing confidence and interest. She believed that she could not do science without more teacher support and this was *not forthcoming, so as she struggled she attributed the failure not to the subject itself but to a combination of her own inability and a lack of support.* Her inability to understand led to her lack of engagement with the subject and thus to boredom. She had at this stage positioned herself outside of the subject in her decision not to pursue it beyond 16. She was expected to achieve in science as she was entered for triple award so her views of the subject and her place in it had not been recognised by her teachers.

Beverley was also concerned about the pace and style of teaching which didn't give her the chance to develop understanding. Her Key Stage 4 experience led her to attribute her alienation to science to the teachers. Beverley is different from Chris, as she recognised that she could be an effective learner. Overall she felt that the teachers made assumptions about the pupils' abilities and did not attempt to understand their position as learners. In Beverley's experience the responsibility for learning was seen to be the pupils not the teachers. Beverley clearly resented this assumption and expected support and understanding for herself as an individual. In her view she was denied access to knowledge (see quote Year 11, line 240, p.183). Unlike Zahadil and Natasha she did not see herself as being able to achieve understanding on her own and felt reliant on the teachers. The feeling of being unsupported led to a gradual falling away from science as she increasingly failed to make sense of it and this was reflected in her achievements, but even more strongly in her view of the subject which she would have walked away from if she could. Her achievements in science (a CC grade) were in contrast to the degree of her alienation, which was marked.

Stephen reported similar experiences to Beverley, but although he felt he needed more support from teachers and that the teaching was often inappropriate, he continued to put in effort to his science study. He, like Chris, was unaware of the significance of, and the nature of, the assessment procedures and methods. He felt that his teachers could have helped with this but he tended to attribute his lack of achievement to himself and remained uncritical of the teaching and the subject. The pace and amount of work made learning hard for Stephen, who needed help to manage his study and this was not recognised.

Nevertheless Stephen continued to believe in himself and his potential as a learner in science. Stephen remained positive about his science experiences, even though he like Chris struggled in Year 10 with some of the core ideas and the ways of working demanded. Like Chris he achieved far less than was predicted given his earlier achievements. His concerns were not with the teaching so much as the subject and teachers' failure to make the subject and its demands more explicit and to consider progress from the learner's point of view rather than the subject. He also needed more support, like Chris, to understand and, in particular, to manage the examination demands. There was a feeling that for Stephen science began to make sense in Year 11 but that was then too late for him to achieve at a level that in his view would allow him to follow a career that involved science. Unlike Chris he did not feel a failure in science but there was a similar sense of lost opportunities as there was with Beverley.

Alan, unlike Stephen, felt that there was a lot of pressure on him to do well because he was in the 'top group' but regardless of that he felt he would be successful. He liked chemistry because he was interested in the subject and he enjoyed the practical work and this increased his motivation. He did not like biology in Year 10 because the lessons were mainly based around copying which he found very boring. Like other pupils he felt that if he was not engaged actively he was not learning and therefore understanding the content. The limitations on Alan's agency were first and foremost an absence of interaction with the teacher and with learning tasks. A consequence of this was that when he was not interested he became bored and did not achieve well. This was something that other pupils commented on too, in particular Chris and Beverley. He had not understood much biology apart from a few topics where he had tried really hard to grasp it. This was a quite different reaction to Chris who faced with boredom tended to give up. He, like Natasha and Hayley, was critical about the quality of teaching in physics and biology. He stated that his teachers did not value what he had to say and this negatively affected his motivation and he found these subjects very difficult in Year 11. Even though Alan had never liked biology he achieved a C grade. He also achieved a C grade for chemistry and a D grade for physics.

Hayley was seen as above average in science but like Beverley struggled with science in terms of its relevance to her. This limited her self-efficacy and her confidence in her ability to learn. Like Beverley

she expected teachers to identify her needs and help her to meet them. She, like Natasha, was critical of the quality of the teaching as well as the lack of support, and together these eroded her enjoyment of science, *this lack of enjoyment was not noted by the teachers who were pleased with Hayley's achievements.* Hayley, like Natasha, was reflective about her learning and felt that she did not understand things properly. This corresponds to a finding from gender research across a number of subjects that able girls are concerned to really understand and are not satisfied with just being able to respond successfully in other people's terms. Hayley's and Natasha's concern with the depth of their understanding of science was not recognised by the teachers *as in both cases the girls could 'do' the work well in the teachers' view.* Beverley on the other hand was concerned that she hadn't accessed the knowledge at all hence couldn't 'do' the work in either the teachers' eyes or her own. Hayley's experience is distinguished from Natasha's because she did not achieve well until Year 11 and by then she had begun to lose her sense of efficacy as a science learner. Consequently in Year 11 she attributed her achievements to luck. She sees her efficacy as *a learner in science to be problematic which in turn limits her self-esteem in science and her perception of her place in the subject in the future.* This is in marked contrast to Natasha who related her lack of understanding to her experiences of the teaching and the nature of the subject rather than to her abilities as a learner.

Throughout Sian's experience of science there is a tension that she expresses about the need for personal relevance and usefulness in her learning and the content and contexts of science as she experienced it. It seems that the significance of this was not identified and therefore addressed by her teachers. The level of achievement anticipated for Sian was higher than that achieved. She achieved grades DD in Double Award Science at the foundation level. Sian appears to have never been 'switched on' to science and the other subjects in her double award experience swamped her early interest in biology. Sian's experience is different from Beverley's in that her teachers expected less of her and less was achieved. Neither did Sian blame the teachers as Beverley did. She valued science more than Beverley, but seemed to see the lack of relevance to be her problem not the subjects or how it was taught, whereas Beverley attributed her problems to the teachers and then to the subject. Sian seems to see her limited achievements as a reflection of her inability in the same way that Stephen attributed his achievements to his lack of effort. A similar

phenomenon was noted by Dweck *et al.* (1978) who found that girls tend to attribute low achievement to lack of ability whereas boys attribute it to lack of effort. A key difference therefore between Sian and Stephen, was that Stephen continued to find relevance and interest in science and hence remained committed to the subject. It's his achievements that removed him from a future in the subject not his own inclinations, whereas Sian, on the other hand, continued to experience chemistry and physics as being without relevance or meaning and her marginalisation in the subject continued through Key Stage 4.

It appears that in Year 10 Stan was targeted for the foundation tier unlike Sian, Beverley or Chris, even though his SAT result was the same. The reason for this is not clear but appears to be related to the teacher's perception of Stan's interest and engagement in the subject. His grades at the end of Year 10 were not that different to Stephen's but Stan was still restricted to the foundation tier. Stan appears to be a well motivated pupil who enjoyed science and like Stephen began to make sense of it in Year 11. Unlike Stephen however he was in the foundation tier and this created problems for Stan because of the disaffection of other boys in the group. He felt that he could have been doing the higher paper rather than the foundation paper if he had worked harder in Year 7. There is a sense that Stan's potential future achievements have been restricted by his location in the foundation tier (an outcome that has been noted generally in research into tiering effects in Key Stage 3 SATs and GCSE, Elwood and Murphy 2002). Stan's location in the foundation tier appears unwarranted given his level of motivation and achievement. It is, however, difficult to move pupils between tiers when they have not been studying at the higher levels since Year 10. In some senses Stan, like Sian, felt that the 'balanced science' approach actually limited his access to science. Stan is denied access to knowledge in a different way to Beverley. Beverley cannot access the subject because she cannot perceive relevance and meaning in it; a common experience particularly for girls that has different degrees of impact on them. Stan's access to the domain is limited by the representation of the subject at foundation level. He and Beverley achieved the same level in double award science (grade CC).

Sam's account suggests that she was not seen to have much potential in science. She seems to accept this as a reflection of her abilities and not something that can be addressed through teaching and support, as she

doesn't blame the teachers or take a critical stance to the subject. By Year 11, like Chris, she had been moved into the Single Award group for science though apparently not for lack of effort, as appeared to be the case with Chris, but because of the level of work she achieved. It is clear that single award science was perceived by the teachers as a lower level of cognitive demand in relation to the subject, rather than different in breadth, (i.e. coverage) to double award science. For Samantha there was a sense that her low self-esteem in science was addressed not by changing the approach to her learning but by ever decreasing the demands placed on her so that ultimately she had the least access to the subject and achieved very little. This suggests that the problem for her learning was attributed to her and not to the subject and its teaching - she was just not able to do science.

The narrative accounts also allowed me to identify common influences and how they are experienced and resolved by pupils. Understanding these common influences I see as a first step toward thinking about how to intervene to make science both more accessible and a more effective learning experience for a range of pupils. To understand what action to take to retain pupils in science and foster self-esteem as science learners, I argue that teachers first need to be aware of what appears to influence pupils' science experiences generally, and second what value individuals accord these different influences as they study science through Key Stage 3 and 4.

At the beginning of secondary school all of the cases enjoyed the excitement associated with being in a school science laboratory and found school science very interesting. They preferred school science lessons to involve them in active participation rather than as passive recipients of information⁵. All cases disliked the increasingly passive teaching style adopted towards the end of Year 9 and continuing through years 10 and 11, particularly in physics. Watts, Bentley and Hornsby (1993) discussed the importance of pupils being active in constructing and re-constructing their understanding, taking responsibility for their learning, using and interpreting data and sharing their understanding. Throughout Key Stage 3 all cases referred to the gradual move away from being actively involved in science learning and the negative impact of that on their interest, enjoyment and engagement with science.

⁵ For discussion see Chapter 5.

All cases (apart from Samantha) felt they were good at school science at the beginning of Key Stage 3. Nine of the cases stated that they enjoyed and learned more whilst being actively involved in practical work, but *the nature of the practical work affected their level of engagement*. Zahadil, Chris, Stephen, Stan and Sian referred to disliking experiments that had predictable outcomes. Black (1993) reported that:

...the style of science teaching has remained largely formal, based on teaching definitions and derivations, and on experiments which illustrated foregone conclusions...(p. 4).

Gott et al. (1994) also argued that it was not surprising that pupils' lack of understanding and interest in practical investigations occurred when teachers and assessors valued and validated the production of scripted and stereotyped reports. Much earlier (Dewey, 1929) argued that involvement in learning should be challenging to thought processes rather than the production of 'correct' answers and that subjects in school should be treated as challenges to thought rather than objects of knowledge.

Most of the cases did not think that sufficient time was given to sharing results with peers for clarification of their ideas and to develop their personal understanding. Boaler's research (1998) in mathematics education argued that pupils would be more effective learners when developing meaning and understanding that extended beyond the acquisition of 'right' answers. Natasha, Beverley, Hayley, Samantha and Sian felt that there was not enough time to reflect on their work and that this affected their level of understanding and interest. Claxton (1997) argued that the process of reflection was important in terms of how pupils viewed their developing sense of self as well as their developing cognitive understanding. This is a self-evaluation process and is important in terms of pupils' self-efficacy. Natasha, Beverley, Stephen and Stan stated that if they enjoyed their work they learned more and that time for reflection was important to their understanding of new information. Hacker and Rowe (1997) reported that a less effective informational, instructional strategy was more popular with teachers implementing the National Curriculum and that instructional strategies, which involved practical work were less frequently employed. In my research this was the case particularly in physics and biology. The teachers in Hacker and Rowe's study argued that the problem was the overloaded, but legally mandated curriculum, which meant that there was too much curriculum content to be covered effectively in the time available. Gipps (1994) discussed the

notion of 'shallow learning' whereby examination or test driven learning strategies were described as being an acquisition of principles without real understanding and commitment. She reported research, similar to mine, where pupils talked repeatedly in interview about not having sufficient time (because of the volume of work to be learnt) to develop their understanding. In my research this finding was particularly related to physics and chemistry. Gipps argued that this was teaching to the test and rushing through the curriculum without the teacher noticing whether understanding has occurred. Five girls (Beverley, Natasha, Samantha, Sian and Hayley) and three boys (Stan, Stephen and Alan) were concerned about the volume of work to be learned in science and the lack of time in which to learn their work effectively.

Science laboratories and other places of learning need to be places wherein pupils are active participants in the learning process and are encouraged by teachers to create, enact and experience situations together because they are negotiating meanings with others and clarifying and developing their shared understanding. Bruner (1986, 1996) argued that learning should be a process of sharing of the culture within a community of learning and classrooms were sub-communities of learners. When pupils are encouraged to actively participate through working together and communicating their cognitive understanding by sharing their developing ideas with peers and teachers, they begin to use this dialogue to modify and generate solutions, as well as beginning to evaluate outcomes of their learning. This process enables them to move from having doubtful and uncertain views towards more predictable ones as their understanding develops. These factors are key features of pupils operating within a community of learning (Hennessey and Murphy, 1999). The importance of mutual participation and interaction between pupils so that they can develop appropriate meanings and the was discussed in Chapter 6. For example Vygotsky (1978) argued that language was a tool of thought and that discussion enabled people to develop their thinking and learning. Bruner (1989) drawing on this argued that referring to others through the mutual use of language was important for individual clarification of ideas. However what the individual appropriated was ultimately a reflection of the shared activity in which the communication occurred. Nine of the ten cases valued discussion because it led to deeper understanding. The study did not examine practice directly, however all of the pupils mentioned that there was limited time for collaboration and referred to experiences of teaching practices that are congruent with a transmission mode of teaching, wherein

knowledge is treated as objective and the teacher has sole authority. I argue that some of the teachers did not engage with learners about their learning in a mutually participative way all of the time or indeed much of the time. *It would appear, although the study itself did not examine this, that some teachers saw this as unnecessary given that they believed pupils could receive information and did not appear to hold a view of learning as a process of reconstruction involving pupils' prior knowledge.* This was supported by the pupils' accounts that failures in understanding were considered to be their responsibility and attributable to either their lack of ability or lack of effort and commitment or both. It was significant in my view that it *was the learners who noted the problem not the teachers, as the learners were aware that the teachers did not understand their difficulties.* Clearly some teachers did engage with the learners in these ways and the cases note this and value it where it occurred.

The majority of cases argued for the need for autonomy and responsibility in their science learning. Bruner (1996) argued that individuals need to be able to perceive what is problematic for themselves and have *opportunities to initiate and carry out activities to resolve these problems by working with others and with guidance from teachers.* The encounters that learners have with such activities help them to position themselves with respect to previous experiences in order to evaluate their prior and subsequent actions. This process of evaluation is integral to the development of learners' self esteem i.e. individual's beliefs about what they are capable of doing in the future and this in turn regulates personal aspiration and level of *engagement with the learning process.*

The desire to work more autonomously can also be linked to pupils having ownership of their work. Cook (1996) argued in his work on negotiating the curriculum, that effectiveness of learning is associated with what he terms the ownership principle:

...that people tend to strive hardest for things they wish to own, or to keep and enhance things they already own. (p.15.)

Many of the cases presented here felt they would be more effective in their learning if they were given more control over it rather than being teacher directed. In contrast, other pupils (Beverley, Sian and Samantha) did not like having the freedom to plan their own experiments. These pupils wanted more

teacher support and guidance at this stage and I argue that this is related to both the pupils' self-esteem and their ability to manage the heavy work load in science. The lack of attention to building pupils' self-esteem in science led to a gradual erosion of their access to the subject irrespective of their potential to achieve in it. This experience can be related to lack of affective readiness as argued by Levin et al. (1987).

Another finding that was common to most of the cases was the concern with relevance and the link between perceptions of the subject's authenticity and pupils' ability to relate to and engage with it. Hofmann and Haussler (1998) support this view and argue that self-concept and interest influence each other mutually. They also related this to gender differences in science interests noting that sometimes girls' lower self-efficacy limits their engagement and interest in school science. In my research relevance was an issue for boys and girls alike and it was clear that its absence had a number of effects depending on the pupils. For some, the lack of relevance severely limited access to knowledge and their ability to achieve throughout their Key Stage 4 experience. For others, the effect on their achievements was less dramatic although they were nevertheless constrained and their potential to access and enjoy the subject was restricted. Significantly these effects on interest and achievement would not be noticed unless teachers reviewed their predicted results, course and tier of entry decisions and pupils' subsequent achievements. For yet other pupils, (who were mainly girls), they could achieve in the terms of the subject and its assessment criteria, but not in their own terms. This meant that they excluded themselves from aspects of the subject. This was particularly the case with physics and to a lesser extent chemistry. Most of the cases were losing interest particularly in physics at this stage as they viewed the subject as irrelevant and fairly meaningless and therefore boring and consequently difficult. This finding has been corroborated in other research (Murphy, 1989 and Reiss, 2000).

Sørensen (1990) found that the 14 year-old girls needed reasons for learning in physics that went beyond internal reasons for teaching and learning in the subject. She found that the girls made more demands about their own understanding of what was going on than the boys. This was the case for Natasha and other girls at Key Stage 4. She also found that boys were more satisfied with physics as they saw the

practical activities as fun. In my research it wasn't until physics and chemistry became more theoretical that boys began to lose interest.

Harding (1996) argued that girls generally worked most effectively within a philosophy of care. She went on to argue that girls perceived, and were reluctant to discard, complexity, thereby opening themselves to charges of hesitancy and irrationality. In my research the girls' narrative accounts were more detailed and elaborate than boys' and this suggests that girls' understanding of their personal experiences was more easily articulated than boys. Girls more frequently discussed emotional responses whereas boys tended to be more pragmatic, particularly in relation to teachers. For example, only boys mentioned that teachers should have been more efficient and controlling whereas girls stated that teachers should have been more respectful and understanding of them as individuals, etc. Chodorow (1978) and Gilligan (1982) argued that females were more emotionally and socially-related to others than males. Fivush (1998) found that girls seem to have a more contextualised view of themselves than boys.

Fivush argues that connections between the developing sense of self within the context of internal and external worlds would not occur unless pupils' experiences in school were purposeful, agreeable and enabled pupils to use their instincts, powers, interests and habits whilst engaging with the learning process.

The narrative accounts in my study provide empirical evidence of what this means in practice for pupils. Whilst there are gender differences that seem significant it is clear that a far more subtle analysis of how pupils' (both boys' and girls') experience of science impacts on their achievements and liking for science is needed to inform practice and future trends in the science curriculum and its assessment.

8.1 The findings of the study

Chapter 2 set the aims of this thesis within a framework of research relating to gender and attitudes in school science over the previous three decades. The major issues for the research were the gendered patterns of uptake and performance in school science before the introduction of the National Curriculum and balanced science courses for pupils aged 5–16 in the UK, the extent to which these had changed, and what, if anything could account for these changes. My key concern was whether the girls and science problem was still a problem, and if so what might lie behind it and thus inform its solution. Many intervention projects were introduced to address the girls' and science problem locally, nationally and internationally. These projects were developed to address a number of issues seen to influence girls' performance in science relative to boys' (Smail, Whyte and Kelly, 1982). These included the reconsideration of the science curriculum in particular the content versus process balance, curriculum material development and its accessibility and stereotyping, and the development of a pedagogy to empower girls (McKlintock, 1989). Other issues addressed were concerned with the importance of valuing different forms of knowledge, including the irrational and subjective (Manthorpe, 1982) and the key importance of socio-cultural issues and the effects of this on learning (Kahle and Lakes, 1983; Manthorpe, 1985; Johnson and Murphy, 1986; Gipps and Murphy, 1994; Anderson and Sørensen, 1995). Research at the beginning of the 21st century, despite many policy changes, mandatory developments and interventions, demonstrates that regardless of these interventions and developing awareness of issues, there continues to be a problem for science generally in the decline in interest in it through secondary schooling, and though girls' achievements at 16 have been radically altered by making science a core subject, fewer females than males choose to study the subject post 16.

My research has revealed that the problem of compulsory secondary science education is no longer best understood as that of girls and science, but science and pupils, though gender issues are still influential and have a major impact on both girls' achievements and views of the subject,

particularly the physical sciences. I identified four areas of concern and will discuss these and the implications for pupils' school science experiences in this final chapter.

8.1.1 Agency in learning

One of the main findings of my research is the degree of awareness that pupils exhibit about what learning activities either support or undermine their engagement and interest in science. The evidence from the questionnaires and interviews demonstrate pupils' advocacy for agency in their learning and their understanding of how constraints on their agency limits the possibilities for their learning. Evidence for this was provided in interview responses in Chapter 4 from Year 7 and 8 pupils. Many pupils discussed practical activity in groups as important to engage them in effective learning. Pupils also stated that they enjoyed group practical work and because of this they were more interested in the subject. Evidence from Year 9 (Chapter 5) illustrated that pupils wanted to take more responsibility for their learning, and to have more time for dialogue in order to interpret and re-evaluate their own understanding. The narrative accounts in Chapter 7 allowed for a much richer perspective on what agency in learning meant for pupils. Most pupils articulated the need for practical activities to be problem solving experiences rather than simple instruction following. Pupils were also able to recognise the need for autonomy and self direction in learning, though pupils varied in their need for teacher guidance and support which could be related to their prior experiences, home support and the subsequent image they had of themselves as learners in science. Some pupils were not aware of the demands of science assessment at Key Stage 4 or of the goals of their science learning and the criteria against which they were assessed. In general it was apparent that teachers made assumptions about the transparency of Key Stage 4 science decisions and choices and these were unwarranted and impacted negatively on pupils particularly the more vulnerable learners in science.

Most pupils valued learning together and recognised the cognitive benefits of collaboration with peers and dialogue with pupils. From the questionnaires and from the interviews there was a clear

mismatch between the experiences that the pupils felt they needed in order to learn and the experiences available to them, this occurred across schools and pupils. The experiences that the pupils disliked and in some cases identified as undermining their learning placed them in a passive receptive rather than active, constructive and reflective role. The accounts showed differences in pupils' ability to understand their own learning and to relate it to their experience of teaching and the nature of the subject. The most reflective of pupils valued understanding over and above success and achievement in school terms and this was more the case with girls than with boys, although the sample is very small so such findings cannot be considered as anything other than illuminative. The more the pupils were able to attribute their difficulties to their experiences rather than themselves, the more alienated they appeared to become from the subject or aspects of it. This was particularly the case where pupils' views of effective teaching and learning corresponded to a social constructivist view of learning and where they had a high level of self-esteem as a learner generally, if not always in science. Pupils who were less aware of what effective teaching and learning entailed were more vulnerable to attributing a lack of agency and understanding to themselves.

Watts and Bentley (1993) discussed the re-structuring of school science education. They argued that as school science was a social construction it could be modified by 'humanising' the whole process thus enabling more pupils to become more actively engaged in their learning. The national Key Stage 3 science strategy is initiating a move towards more active science but the research from my thesis does suggest that assumptions about teachers' beliefs about learners and their needs need to be exposed and reconsidered through a wide range of evidence before pedagogy can be changed. My research also highlights the need for such evidence to include pupils' lived experiences so that issues like pupils' alternative conceptions are understood within the contexts of the possibilities provided for learners to construct scientific understanding. A further finding was the need to make explicit the learning goals and assessment procedures for pupils rather than to assume that they are transparent. Associated with this is a need for teachers to review their judgements about pupils working with pupils throughout their science experience. The move to introduce assessment for

learning as part of the Key Stage 3 strategy will help with this but it leaves two aspects of assessment in science unchallenged. The first is the allocation of pupils to different science courses *on the basis of the teachers' perceptions of potential and effort and the limited opportunities* for these to be applied flexibly and in dialogue with pupils. The second is the allocation of pupils to tiers of exam entry that can set ceilings and floors on their achievements. Research has shown that this influence begins in Year 7 and is in operation in the science Key Stage 3 SATs. The research also shows that gender differences in allocation to tiers of entry in Key Stage 3 SATs determine the *levels of pupils' achievements often on the basis of affective rather than cognitive issues* (Elwood and Murphy 2002).

Gender is not well addressed in the Key Stage 3 strategy. Active science takes account of agency at an individual level but beyond this constructivist approach it is important to further explore socio-cultural issues that relate to the nature of the learning environment and the possibilities for learning. The research highlighted the significance of teacher – pupil relationships and the levels of respect accorded to learners in the learning environment. This was seen by pupils to be a key feature of the support needed for effective dialogue between learners and their teachers. Research corroborates my position that gender issues in particular, are not being addressed by current changes, for example supporting different learning styles, prior learning experiences and the way in which girls and boys' interpret tasks in school because of these experiences. Boaler's (1998) research in another domain (mathematics) corroborates the view that the influence of gender is not being addressed appropriately, as does research in science education, as described by Hildebrand (1996), Whitelegg (1992) and Reiss (2000). Boaler's (1998) key point about the learning environment in maths was that the girls (top set) found the fast pace did not allow them to develop a depth of understanding. They found the learning environment unsupportive of their learning and this limited their ability.

8.1.2 The nature and function of school science

Most pupils (girls and boys) were losing interest in school science by Year 9 and this was associated with the pedagogical styles adopted as well as the increasingly abstract content. A particular feature of science that pupils reported influenced their ability to engage with it was its lack of relevance. What pupils saw as relevant was very much a reflection of their everyday lives hence there was some indication of gender differences here particularly in relation to physics content. Many boys and girls struggled generally with abstractions that they could not perceive had any functionality and this was the case with chemistry as well as physics. Choosing activities that engage pupils actively usually requires teachers to pay attention to context and purpose in order to allow pupils to formulate tasks for themselves that are within their abilities to address. The gradual erosion of pupils' agency in their science experiences goes hand in hand with a loss of relevance and meaning in their learning experiences.

Chris (Year 11) commented that one problem with school science was that it was not related to social contexts or to how it may affect his future life. Aikenhead and Jegede (1999) argued that when the culture of science is at:

...odds with a student's life-world, science instruction will tend to disrupt the student's worldview by trying to force that student to abandon or marginalise his or her life-world concepts and reconstruct in their place new (scientific) ways of conceptualising. This process is assimilation...can alienate...causing social disruptions. (p.274.)

Recent research (Reiss, 2000) on school science lessons found that most pupils lose their initial interest in science over the five years of their compulsory secondary science education. This was clearly evidenced in my research (Chapters 4, 5 and 7). One of his main conclusions was:

...that school science education can only succeed when pupils believe that the science they are being taught is of personal worth to themselves. (p.155.)

Reiss went on to argue that pupils perceive the worth of school science differently and that some pupils value school science because of its value in further education. He found that others perceived the value of school science in helping them to understand their place in the world. This

pupil diversity supports the notion that there is more than one reason for learning about science and was reflected in the different perspectives of my cases in chapter 7. He argued that a way of *teaching science and the science curriculum must engage the concerns of pupils* or little effective learning will take place. Evidence from pupils in all years of the research supports this view (Chapters 4, 5 and 7).

Initially girls were identified as the 'problem' in school science but the research focus shifted eventually to identifying the content of the science curriculum as being contributory sources of inequality. Harding's (1986) described gender relations as being affected by gender dualisms related to non-biological dichotomies for example rationality and irrationality, abstract or contextual science, physical science and biological science. Academic environments, I have argued, are based on a view of knowledge development that assumes that knowledge is rational and objectively gained through logical analysis. Science is perceived by some as a masculine subject because it incorporates this abstract rationalism. As mentioned earlier these abstract and positivist views of science often work to reproduce gender segregation in schools. Belenky et al. (1986) interviewed adult women about their preferred ways of knowing and from this classified five 'ways of knowing'. They argued that a view of knowledge held by females was one related to intuition and personal experience. Almost half of the women responded in the 'subjective knowledge' category in which knowledge and truth were perceived as private, subjectively known and personal. When some females with this subjective epistemology enter the educational environment, which often emphasizes scientific thought and rationalism, they must change their focus and this may cause conflict. Within school science there is missing the 'human element' and 'morality' and this can alienate females. To reduce these difficulties the teaching and learning environment must be more accepting of the multiple ways of gaining knowledge. In my research girls more than boys alluded to problems in the teaching and learning environment and felt that their teachers did not understand their learning difficulties with some abstract scientific concepts. This lends weight to the view that more girls than boys value understanding over and above the more simple demands of the science curriculum and its assessment. However my research also

showed that relevance, meaning and functionality were issues for some boys and their absence had a detrimental affect on their learning. Furthermore a social constructivist and socio-cultural view of learning that underpins the analysis in Chapter 7 argues for an associated view of knowledge as subjective, situated and distributed. Hence the issue of how knowledge is represented and realised in science classrooms is no longer a gender issue per se, rather a learning issue for all pupils and their teachers. The research does suggest that any moves to alter how knowledge is represented in the science curriculum will not only have to take account of teachers' pre-existing beliefs about this but also those of pupils who have acquired their understanding through their science experiences. The study and other research suggest this may cause more problems for some boys than some girls. My cases illustrate that boys more than girls, tend to be more accepting, and thus less challenging of the relevance of science content, (only those boys that cannot make sense of it). Stephen stated that providing a context for learning was confusing.

My research evidence indicates that for pupils (particularly girls) to become more engaged with school science learning, school science education reform must involve the deconstruction of the biological science/physical science dualism, as well as the abstract/context dualism. Chapter 2 outlined research literature (for example: Ormerod and Duckworth, 1975, Gardner, 1975, Smail and Kelly, 1984) that reported boys were more interested in physical sciences and girls were more interested in biological sciences. Evidence from Chapter 4 supported this position for pupils in Year 7. National surveys (DES, 1988a, 1989a and b; Qualter, 1993) had found across the ages that all pupils preferred biological to physical science topics. This was not the case in my research in Year 8 where boys showed a preference for physical sciences and girls did not express a preference for either discipline, but it was the case for most Year 9, 10 and 11 pupils. The most popular topics in Year 7 were the human body, animals, food and electricity and in Year 8 the environment, magnetism, acids/alkalis and materials (the popularity of these topics, I would argue, is associated with the high level of practical work involved).

Evidence from Year 9 pupils (Chapter 5) explained pupils' rejection of physical science topics and acceptance of biological science topics because the latter were more readily related to pupils' everyday worlds and contexts. *Many more Year 9 girls than boys discussed the lack of relevance of much of the physical science curriculum.* Further evidence in Chapter 7 corroborates this position.

Science in schools is often perceived by pupils as 'real' science and is associated with rote memorisation of facts rather than leading to a more informed understanding of how school science is relevant to pupils' lives in the future. Ramsden (1998) argued that school science was perceived as:

...being difficult and not relevant to the lives of most people, of science causing social and environmental problems; that science is more attractive to males than females; that interest in science decreases over the years of secondary schooling; that these more negative views are associated with the physical sciences rather than the biological sciences. (p. 125.)

The Dearing report (1993) recommended slimming down the National Curriculum to reduce the content. Millar (1996) argued that a reduction in content would not be enough to make room for processes in school science that are contingent with constructivist approaches to teaching and learning. These approaches may therefore fail because exam led, time limited science curricula will not allow pupils opportunities to make connections between the facts/knowledge they are expected to absorb and their life experiences (as evidenced in Chapter 4, p. 114-115 and Chapter 5, p.137).

The McKlintock Collective (1989) suggested that the content of science lessons had to be changed and reconstructed so that it becomes a more co-operative and human activity. They used creative writing, drama and tinkering activities in science lessons over a six-year period to achieve this.

Gianello (1988, cited in Hildebrand and Dick, 1990) argued that:

Science is speculative, creative and absorbing! It is a challenging area that involves being curious, taking risks, sharing ideas and caring about the quality of our lives and our world. (p.172.)

Research presented at GASAT conferences (for example, as described in Vlaeminke et al. 1997) argues that a sociologically and philosophically informed science curriculum and its associated pedagogies are *beneficial and interesting for girls, but also for all pupils*. Byanyima (1994) supported this position:

All sciences ... arise out of people's historical experiences and as such carry values and *cultures of the people concerned...[science can only be] meaningful in a social and cultural context*. It carries the values of the society where it evolved. (p.59.)

Debates about the nature of science have, however, raised questions about the extent to which science is seen as socially and culturally determined.

The key issue, which is still strongly disputed, is whether it is the social processes affecting the relevant scientific community, or the features of the natural world, which are the *principal determinant of scientific knowledge*. (Driver et al. 1996 p.39.)

Osborne et al. (1996) suggested that many teachers and scientists defended the positivist view of scientific knowledge as a better model than constructivism for school science. Roth et al (1996) agree that the dominant paradigm driving science education is based around indoctrination into an objectivist conception of science. Woolgar (1988) argued the importance of understanding that knowledge is not a faithful reproduction of reality but is a product of human activity. Social constructivists (for example Rose, 1994) are in agreement that social, cultural, political and economic factors shape science and technology. Proponents of the sociology of scientific knowledge argue that scientific knowledge as well as scientific aims and methods are socially constructed. Bruner (1996) argued that for many school pupils:

...science has come to seem "inhuman" and "uncaring" and "off-putting" - despite first class efforts of science and mathematics teachers. (p. 42.)

He suggests that science may become more a part of a human and cultural undertaking if it were to be conceived more in terms of a history of human beings overcoming received ideas, for example, Darwin re-thinking respectable creationism.

8.1.3 Reconceptualising gender and attitudes

Research has indicated that gender is a significant influence and is mediated by other social and cultural factors. The success of any reformulation of the science curriculum depends on people's understanding of gender and how it acts to mediate pupils' experiences and teachers' practice at school, local and national policy levels. In my teaching experience I often heard teachers referring to pupils' (mainly boys) negative attitudes towards school science. The view was that unless they were changed, teaching these pupils would be very difficult. Inherent in this type of comment was a belief that gender and sex group were interchangeable and that diversity within groups was not recognised. In my practice I did not treat or experience my teaching groups as a homogeneous units, but as groups of diverse learners each with their own experiences in terms of both their previous science education and their socio-cultural background.

I had the advantage of being aware of Equal Opportunities legislation and the variety of national and local interventions (during the 1970s and 1980s) that were designed to address inequality of opportunity, and I was specifically interested in gender equality and science education. In my broad range of science teaching experience I noticed that many teachers often segregated pupils by gender and these gender segregation practices did not make sense to me. I wondered why pupils should be lined up outside laboratories in terms of their gender, why piles of books were separated by gender, and why gender was used to manage the distribution of equipment for practical work (for example girls to collect equipment first). My colleagues, on the other hand, could not understand why pupils should not be grouped in such a manner. These experiences made me realise the numerous underlying assumptions held by teachers (and society at large) about gender issues.

My research also uncovered the way that some pupils appropriate these views. During interview in Year 7 and 8 pupils stated that they felt science was not a gendered subject although gender

stereotyped views of the way boys and girls are (for example girls are better at writing) were commonly alluded to (Chapter 4, p. 106-108).

Johnston and Dunne (1996) have argued that findings from research that examines social constructs like competition and collaboration, dependence and independence, compliance and aggression statements have been taken to represent the 'truth' about girls and boys in science and mathematics. For example, girls prefer collaborative learning environments, girls prefer to share and support each other in tackling problems, and girls need encouragement to build their self-efficacy and self-esteem. In the process these truths have become widely ascribed to biological divisions and therefore assumed to characterise all individuals in a sex category. Ironically the relationships that such gender research was trying to challenge (the dominance of masculine over feminine) was therefore reproduced through these oppositions. Girls as collaborative, dependent, and compliant were differentiated from boys who were aggressive, dominant and independent. But, in learning science, competition, aggression and independence are valued.

These stereotypes represent an essentialist view of gender and treat girls and boys as homogenous groups of science learners. One message from my research is the need to consider people first and foremost as unique and to do this teachers need access to ways of reconceptualising gender to allow for its influence without treating it as an attribute of people that is static and unidirectional. Fivush (1998) argued that biological sex and social/cultural conceptions of gender, codified in cultural stereotypes, interact with children's own developing cognitive understanding of what it means to be female or male. Weiner (1994) argued that these rigid hierarchical structures that are cultural stereotypes worked to segregate females in science and did not allow for individuals being active agents in constructing gender and determining its influence. Gardner (1998) and Fivush (1998) argued that the gender construct was better understood as a system of values. In Chapter 2 I argued that both gender and attitude were better understood as social forces operating as dynamic processes rather than fixed entities. My review of the literature discussed in Chapter 2, illustrated both the diverse interpretations and the contentious nature of constructs that are said to represent

attitudes. During my research for this thesis I moved away from the rather naïve position that attitudes were 'things that pupils had' and could fairly easily be measured, as suggested in early research on pupils' attitudes. *Pupils cannot be classified as having positive or negative attitudes towards school, or particular subjects, as the way in which pupils perceive themselves within any situation, including their school science experiences, is dynamic and subject to a multitude of influences. I argued that both constructs are processes influenced by emotional and cognitive factors and mediated by, as well as inextricably linked to, societal mores and their representations in school, and outside of school by parents, peers, teachers, and individuals.*

My research therefore developed from a fairly simplistic notion that attitudes related to pupil's gender could be measured (survey data collated and presented in Chapter 4) towards a more holistic exploration of individual pupil accounts of their school science experience and what they identified as influential in this and the nature of that influence (interview data collated and presented in Chapters 4, 5 and 7). Duveen and Lloyd (1986) argued that an individual's social identity emerged during social activity where social identity is reflected by the individual's effort to become situated within their perceived social representation in their own society. In Chapter 6, I provided evidence from the literature about the web of interrelationships between the socio-cultural environment and the individual pupil. Freeman Dyson (1995) argued that science was:

...a human activity, and the best way to understand it is to understand the individual beings who practice it. (p. 11.)

Kenway (1996) reviewed research into self-esteem and concluded that the social environment was a key influence. She argued that self-esteem is not the problem of the individual which in her view is the position argued by Dweck et al. (1978). In her critique of their work she stated the findings were really about the:

...powerful impact of social agents on self-concepts. (p.25.)

In Kenway's view problems with self-esteem are influenced by the social environment and therefore research programmes should explore the way in which these influences impact on the

individual. As part of this examination she argued that the programmes should consider teacher expectation, the learning environment and societal attitudes.

Bruner (1996) argued that schools must constantly reassess what they do to young people's:

...conception of their own powers ... and their sensed chances of being able to cope with the world both in school and after...(p.39.)

He went on to argue that the ways in which pupils coped with their learning was suffused with affect (beliefs, values, feelings and respect) and the development of self-concept was a dynamic process. This process was related to pupils' agentive efficacy (the conception of their own power) and this was dependent on their autobiographical memory and prior experiences as well as what individual pupils felt they were capable of achieving. Self-concept development was also associated with what pupils feared was beyond their own capabilities and this was in turn dependent on success or failure that is culturally specified, and is reflected in how pupils evaluate themselves.

In my research there were many commonalities in response from girls and boys about their school science experiences as illustrated in survey and interview responses but there were also some gender differences emerging. Data in Chapter 4 (from the survey of Year 7 and 8 pupils) illustrated (with statistically significant differences) that boys had higher levels of self-efficacy than girls in some aspects of school science. The majority of Year 7 pupils found school science exciting but by Year 8 girls were less excited by science than boys. Boys were more interested in science and perceived school science as more important to them than girls. More girls than boys disliked the abstract and seeming irrelevance of much science content and were more concerned about the lack of time to learn their work effectively. Evidence from Year 7 and 8 girls is presented in Chapter 4 (p.113).

Further evidence presented in Chapter 5 showed that pupils considered that boys were better at science than girls. By Year 9, perceived levels of self-efficacy in science, excitement with science

and importance of science had decreased significantly for all pupils, but more so for girls than boys. Girls more than boys in Year 9 were concerned about pedagogical style and teacher relationships *in terms of levels of support and respect and the absence of these had a negative effect* on their learning and interest in school science. This is supported by evidence cited in Chapter 7

8.1.4 Understanding pupils' positioning in science

From the questionnaire findings I learned that there were more similarities than differences between girls' and boys' responses. But during interview it was increasingly apparent that there were differences in pupils' dispositions towards school science and some of these differences were gender related and others were not. The first three to four years of my research was a huge learning experience for me. I moved away from relatively simplistic notions of pupils' attitudes to a position that recognised the importance of the holistic nature of pupil learning and individual pupil's positioning within this process. I argued in the thesis that looking for some concept or construct of attitudes to explain science achievement is not productive to understand either achievement or how pupils feel positioned in relation to science. All of my cases moved or removed themselves from science or at least aspects of it; some were given very little access to it, whereas others who had access rejected it. My cases' uniqueness helps to demonstrate how there is no simple direct relationship between achievement and liking for or enjoyment of a science. By applying a social view of learning and knowledge that assumes that what is experienced by individuals is unique because it is mediated by what they bring to the experience, I have helped to show how individuals react to common experiences in science. I have gone on to illuminate on how this impacts on their achievements and liking for science and their future engagement with it. Bruner (1996) argues for the uniqueness of each person by describing an individual as a 'self with history and (future) possibility'.

Many of the cases referred to teacher effects on their learning and there were some key gender differences *emerging, although there was overlap between girls' and boys' responses. There were*

a number of dimensions to this effect, one was to do with teachers' expectations and this clearly affected some pupils like Chris. For other pupils like Stan the teacher's low expectations were embedded in the tier of entry decision but this seemed not to impact on Stan's motivation and views of himself as a learner. For some pupils the effect was related to teacher support but it was clear that the support needed varied. For some like Chris and Stephen it was support to understand the assessment procedures and to manage workload. Both boys said they needed help from their teachers to keep them working hence their reference to the need for greater strictness, as it appeared that *intrinsic motivation was not enough*. Although Zahadil made the same comment he did appear to have sufficient intrinsic motivation to overcome this. Stan needed help from the teacher to maintain a disciplined learning environment to enable him to do his work indicating that he was both motivated and diligent. These findings shed some light on what might lie behind the common gender stereotype that girls and not boys, are diligent and perhaps provide more informed insights about what type of help some boys need. Pupils like Natasha, Hayley, Sian and Beverley wanted teacher support to overcome their inability to access the subject and understand its relevance. These differences in pupils' views of the support needed are significant as they had a differential impact on pupils' perceptions of their relationships with their teachers - an important finding in my research. Beverley and Natasha understood their problem with access to be a problem with the teaching and the subject that they felt their teachers should take responsibility for. The teachers' perceived failure to do this and to attribute any difficulties to the pupils had significant consequences in some instances for achievement, but in each case for the pupil's view of the subject and its value in relation to themselves, that in each case was reduced. Stephen, Beverley, Hayley, Natasha and Sian felt it was essential to have good teacher relationships for their learning experiences to be effective. In my research feeling able to ask questions and to seek support for developing personal understanding was a more important issue for girls than for boys. I would however argue that it is equally important for those pupils, both boys and girls, who attributed failure to themselves but my study revealed that these pupils were not aware of its significance for them. Samantha, Stan and Chris, although they experienced teacher effects, did not identify any problem with their relationship with their teachers. A number of cases (only one

boy) claimed that their ideas were not listened to or were not valued by their teacher, and that there was insufficient opportunity for productive and positive dialogue with both teachers and peers. Only girls mentioned the importance for their learning of liking their teachers. Their liking was limited when their teachers did not understand their difficulties or listen to them as individuals, made them feel uncomfortable asking questions, and incompetent. This reduced their self-efficacy and their interest in the subject. Driver and Oldham (1986) argued the importance of the teacher's role in sensitively mediating the affective environment to support free expression without threat, if *there is a sense of threat this will negatively influence pupils' judgement of their capability and thus their level of self-efficacy*. Clarricoates (1987) argued that girls' conformity to feminine stereotypes reflected in their diligence and conscientiousness makes them less 'bothersome' to teachers who are more likely to give attention to boys and respond more positively to them. Only one boy mentioned that it was difficult to develop good relationships with three new teachers at Key Stage 4. Chris, Zahadi and Stan thought their teachers were good but they should have been stricter. No girls mentioned that they felt their teachers should have been stricter. Bruner (1996) argues that learning and constructing understanding involves the development of self-image. This process of reconstruction involves both cognitive and affective changes and can be potentially threatening so it is important that the learner feels valued. The sharing of ideas requires an emotional investment as it involves self-image as well as cognitive reconstruction. Murphy (1989) argued similarly that the modification of existing ideas is influenced by self-image and personal knowledge. The girls in my research used language in such a way that enabled them to locate their experiences within their sense of developing understanding of self in relation to the world.

An implication of my research contribution is that teachers need to monitor more closely individual's experiences and concerns. To inform this I have highlighted some of the influences that learners identify as factors that affect their achievements in science because they affect their enjoyment and interest in it, this in turn affects the quality of their engagement and understanding of science. These influences relate to: schooling and assessment procedures generally, including how these are understood by the pupils and their families; pedagogy including fundamental aspects

such as whether learners are allowed an active role and given autonomy in and responsibility for learning and whether knowledge is represented as subjective, situated and functional; and features of the subject itself, i.e. *how it is represented in teachers' approaches and the specification of content in the formal curriculum and its associated assessment at Key Stage 3 and 4*. My research lends support for some of the current initiatives in science at Key Stage 3 and 4, and suggests possible limitations and/or oversights in these. For example to what extent are the policies informed by evidence from pupils and is that evidence set in the context of the possibilities for learning made available to pupils in different school circumstances? Perhaps cases like those presented in Chapter 7 are needed to help teachers understand the impact of their practices in implementing policies on the lived experience of pupils. I also have some concerns about the tiering process that occurs in science at Key Stage 3 and 4. There is evidence (Elwood and Murphy, 2002) that pupils' achievement can be misrepresented by being greater than that allowed for by the grade range (the ceiling effect, as occurred in Stan's case) or by being lower than that allowed by the grade range (the floor effect). As Elwood and Murphy argue the:

Ceiling and floor effects reinforce for both teachers and students stereotypical expectations of present and future performance. (p.399)

Teachers do experience difficulty selecting levels of tiered entry that ensures fair representation of pupils' current and potential achievements. There is also evidence of inequality associated with tiering processes, particularly with respect to gender. The way that different science courses are put in to practice in schools, such as the hierarchy of triple, double and single award science also has potential inequalities embedded in it which warrant review before new structures are established that assume that teachers can make decisions on pupils' behalfs about their access to the domain and their future in science, and have the necessary evidence and expertise to do this.

8.2 Implications for further research and the contribution of the study

Possible areas for further research are proposed in the light of evidence and findings presented in this thesis. During the research period there have been rapid changes in government education policy, with little time for consolidation or evaluation. There have been improvements in performance at GCSE science, particularly for girls, since the introduction of the National Curriculum and balanced science courses. But there continues to be little uptake in science subjects post 16. School science policy developments are still failing to meet the needs of pupils and there is a failure to capitalize on pupils' earlier interest in school science. The National Curriculum and its associated testing regime have shaped practice and this has led to a significant reduction in opportunities for pupils to experience creativity in science at school and to experience the nature of the domain and its cultural basis. Though these remain contentious issues that need to be the subject of continuing debate their absence in pupils' experiences currently is increasingly accepted. More research on individual pupil learning taking account of their thoughts and feelings about these processes are needed to improve the quality of teaching and learning in school science. It is important that the cultural processes of meaning making within individuals' learning experiences are not ignored in school science education. There needs to be more awareness of the mediating effects of social representations (school, subject and gender) on the teaching and learning process. This requires a far wider conception of pupils' prior knowledge than is currently taken into account in traditional constructivist approaches to teaching and learning. This research would inform the development of critical pedagogic approaches that recognise the significance of both teachers' and pupils' interpretations of social representations at an individual level, at subject level and school level in initial and future professional development.

Challenges to the validity of the data collected in this research relate to problems associated with generalization and transferability of findings. However the thesis is premised on a developing rationale that experience is personal and by foregrounding the intrapersonal whilst keeping other planes of analysis, including the inter and community planes, in the background we can begin to

develop universal understandings that are contextualised and rooted in the personal experiences of learners (Simons 1996). Validity is also affected by the researcher's subjectivity in constructing meanings and understandings through the selection of data for inclusion in the accounts. A socio-cultural approach to understanding learning makes this inevitable. The mix of methods and the attempt to seek pupils' endorsement of their accounts was a way of ensuring the validity of these selections. Interviews of pupils in groups were extremely valuable in terms of pupil subjectivities. I was always concerned with the possibility of multiple interpretations of individual accounts. I collected data longitudinally from pupils (who had experienced the National Curriculum from age 6 years) and used this data to reflect, as accurately as possible, pupils' understanding of their own views on this experience, how their views changed over time and how school science learning experiences could have been improved for the individual.

My research could have been improved if I had also observed the pupils in their lessons. This would have provided me with insights to validate what pupils shared with me in group interviews. However at the initial stage of my thesis I would not have been aware of what observations to make i.e. what would constitute critical moments for pupils' learning and teachers' teaching in the teaching and learning environment. Hence the scale of such a study that was envisioned as longitudinal would not have been feasible for a doctoral study. The narrative accounts do begin to suggest what observations of practice might serve to inform teachers of practices that support and undermine particular learners. They also provide support for the validity of some current developments that seek to establish communities of learning in science settings in schools.

Through my case studies I focused on the way in which individuals' were positioned with respect to their school science experiences. The narrative accounts raised many issues. These varied for individual pupils, for example Stan achieved a CC grade at GCSE but could he have achieved better had his opportunity to learn not been restricted by tiered entry? Would he have seen himself as a more central participant in science if his teachers' expectations had been closer to his potential? Stephen and Sian eventually achieved D grades in double award science, but what

happened to them cannot be fully understood from their accounts. Yet would Stephen have continued and probably succeeded in science if he could have built on his Year 11 success when the subject began to make sense? His time spent in trying to work out what he had to do to meet the assessment requirements detracted from the time available for his learning. Whereas Sian felt that single subject science would have been the best route for her success indicating that having to study subjects that had little meaning for her alienated her from the subject generally in spite of her interest and achievements in biology. How would a new curriculum that advocates science for public understanding as the most relevant for pupils like Sian have altered her experiences?

Whilst Zahadil was an apparent successful science learner he gave up on physics. He also had few opportunities to engage critically with the subject and experience its nature during Key Stage 3 and 4. He was never critical of the subject, but he turned away from physics. To what extent were his achievements constrained and to what extent was he choosing to engage with a subject whose nature he never really understood in his future chosen profession? Natasha was another able student who rejected physics and to some extent withdrew from further engagement with a curriculum that was overloaded with content and exam led. She took against science but in many respects was not allowed access to its social and cultural basis and so could not adopt the critical reflective stance that she valued in her learning. The relationship between science as represented and enacted in higher education and its representation and enactment in schools has been criticised in recent policy proposals. However it was this relationship that made Natasha choose not to study medicine. Will current proposals for science at Key Stage 3 and 4 have any impact on how medicine is taught at University? Hayley also rejected science but was damaged in the process because although a successful learner she felt no sense of ownership in her achievements and attributed them to luck. She therefore not only rejected aspects of the subject as not for her she also positioned herself outside of the subject – it was not a place she belonged. How do teachers decide if pupils like Hayley are candidates for academic science, vocational science and/or science for public understanding? Do these choices address the problems that Hayley experienced in not being able to value her achievements? Beverley was another alienated learner who considered that her

experience of science denied her access to the domain. She held the teachers responsible for this because of their practice rather than the subject itself. Chris and Samantha were also denied access to science like Stan, but would their achievements and engagement with science have been better if they had not had a ceiling on achievement in science imposed? But, Chris accepted the responsibility for his lack of effort as did Stephen. How could Alan's loss of interest in biology have been stemmed and would this have affected his achievement in the other sciences? Answers to questions of this nature can only be attained by further in-depth research.

My research is unique in a number of respects. Firstly it provides evidence from pupils that their decline in interest in school science over their secondary schooling is associated with teaching and learning processes that constrain their agency and responsibility for their learning. Part of this experience of loss of agency is attributed to the lack of authenticity in school science experiences. The data provide insights into the practices that pupils' value in developing understanding that they can retain and use in new situations to inform and regulate their future actions. Secondly I explored pupils' evolving perceptions of science as a school subject as part of pupils' developing sense of self and the dynamic interrelationship between these. I did not observe this dynamic directly but explored some of its outcomes at fixed points over time during pupils' secondary school science experiences. This approach allowed me to challenge more traditional approaches to attitudes both in their conceptualisation and measurement. In so doing I brought together related conceptualisations of gender and attitudes. This allowed me to provide a more subtle view of gender mediation that emerged first from individual experiences out to common influences, though not effects. A further contribution that this approach allowed was to show how there are no simple relationships between achievement in science and liking and engagement in it

Finally the research provides evidence from a range of narrative accounts illustrating the relative positioning of pupils within their school science experiences, these accounts are key in understanding how pupils experience teachers' practice and react to these experiences regardless of their gender. In my literature review (Chapter 6) I identified the complexity of the learning process

within which pupils' developing meaning is a process that incorporates individual construction and re-construction of understanding, simultaneously with the construction and re-construction of self-identity, *so that learning is understood as a transformation of identity*. I used the concept of selfhood and the related concepts of self-esteem and self-efficacy as analytical devices to demonstrate the personal nature of pupils' experiences. I focused on how pupils were both positioned and positioned themselves within the curriculum experiences enacted by their teachers. In the past, attitudes were studied as attributes of pupils because educators wanted to discover how they could be changed at a general level. In my research I provide evidence to show the limitations of such an approach and at the same time identify some of the mediating influences teachers need to be aware of, how these impact on pupils and the ways in which individual pupils react and resolve the dilemmas that emerge from such impacts. A major message from the research is that teachers will develop further insights into their practice and how to make it effective by providing *learning environments that allow dialogue between teachers and learners, and learners and learners*, and where dialogue about learning is the norm, not the rare phenomenon it currently appears to be. This dialogue however is premised on particular views about the nature of learning, learners and knowledge and as such can only occur if teachers are convinced of the validity of these views and the efficacy of the pedagogy that such views imply. Evidence of the sort that the thesis provides may help in making this case for a change for both teachers and pupils alike. This position is supported by a student review of the science curriculum (Cerini, Murray and Reiss, 2003) that concluded:

A system needs to be put in place to ensure that decisions that affect students cannot be taken without taking students' views into account. (p.19)

My research in foregrounding the pupils' voice and experiences makes clear what an invaluable source of insight they provide to inform teaching and learning. It is a sad irony that pupils' eloquence and awareness of the characteristics of effective learning emerge in their accounts of experiences that typically fail to provide them. It is salutary too, how, in spite of their awareness pupils continue to try and make sense against the odds. The research began with a concern about the problem of science and girls. It rapidly shifted to a view that the problem was science and

pupils. The evidence in the thesis argues the need to recast the problem as one to do with the specification, and assessment of school science and how this shapes practice. The pupils aren't the problem.

Appendices

Appendix 1.

Survey samples by school and gender

School 1

Form	Number of pupils selected	Boys	Girls	Total in year = 273
7.1	14	6	8	
7.2	12	7	5	
7.3	7	3	4	
7.4	10	7	3	
7.5	11	4	7	
7.6	9	5	4	
7.7	13	6	7	
7.8	6	4	2	
7.9	8	3	5	
Total	90	45	45	

School 2

Form	Number of pupils selected	Boys	Girls	Total in year = 180
7M	10	2	8	
7W	4	2	2	
7S	11	5	6	
7N	12	7	5	
7D	12	8	4	
7H	11	6	5	
Total	60	30	30	

School 3

Form	Number of pupils selected	Total in year = 178
7C	9	
7D	7	
7F	11	
7M	13	
7Tt	10	
7X	8	
Total	58	

Appendix 2

Science questionnaire

Name: _____

Sex: _____

Date of birth:

Day _____ month _____ year _____

Class: _____

Science Teacher: _____

School: _____

Please answer all questions following the instructions given. Thankyou. G.Sharp 1993.

Draw a circle around the face, which fits your response to the question most closely.

1. How well do you think you will do in science?



2. Do you think you are good at science?



3. Do you think you are good at problem solving?



4. Do you think you are good at explaining what you have found out?



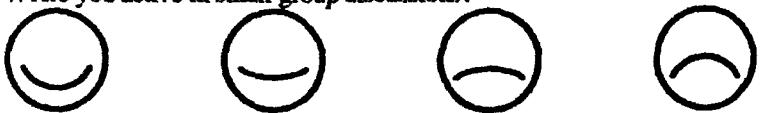
5. Do you think you are good at practical work?



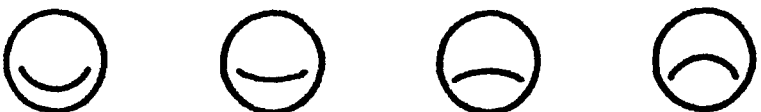
6. Are you good at writing up what you have done?



7. Are you active in small group discussions?



8. Are you active in whole class discussions?



TICK A BUCKET WHICH MOST CLOSELY SHOWS HOW MUCH YOU ENJOY THE FOLLOWING (a full bucket if very much, an empty bucket if not much):

9. Do you like working in small groups?



10. Do you like doing practical work?



11. Do you like writing about what you have done?



12. Do you like being active in small group discussions?



13. Do you like whole class discussion?



14. Do you like using the Bunsen burner?



15. Do you like asking for help in practical work?



16. Do you like asking for help with written work?



17. Do you like explaining what you have found out?



18. Do you like problem solving?



19. Do you like making up your own experiments?



20. Do you like science?



OUT OF THE FOLLOWING LIST TICK 8 THAT YOU MOST ENJOY

acids/alkalis
microbes
forces

materials
space
measuring

environment	separating things
human body	food
energy	magnetism
plants	animals
health	electricity

PUT A CIRCLE AROUND THE BEST ANSWER TO THE FOLLOWING QUESTIONS:

- | | |
|--|-------------------|
| Q.21 Do you prefer working with friends in science group work? | yes no don't know |
| Q.22 Do you think science is a boys subject? | yes no don't know |
| Q. 23 Do you think science is a girls subject? | yes no don't know |
| Q.24 Do you think science is exciting? | yes no don't know |
| Q.25 Do you think science is boring? | yes no don't know |

Appendix 3

Information sheet for teachers distributing questionnaires.

Please ask pupils to:

- fill in the information data on the front page
- respond to all questions on the sheet

Please explain to pupils that where questions had smiley faces or buckets they indicate the following, from a very positive response to a very negative response:

- | | |
|-----------------------------------|--|
| • very smiley face or full bucket | very well at /very good/very much |
| • small smile or half full bucket | pretty well at /pretty good/pretty much |
| • sad face or nearly empty bucket | not very well at/not very good/not very much |
| • very sad face or empty bucket | poor at /not good at all/not much at all. |

Appendix 4

Pre-interview question sheet

1. Tick the activities you like best or you are good at in your science lessons.

You can choose up to 5 activities in each column:

	like best	good at
practical work	—	—
class discussion	—	—
posters	—	—
making notes	—	—
group work with friends	—	—
group work in other groups	—	—
making up experiments	—	—
problem solving	—	—
thinking science	—	—
writing up experiments	—	—
using worksheets	—	—
drawing diagrams	—	—

2. Do you think you are really good at science?

Yes ___ No ___ Don't know ___

3. Do you think science is easy or hard?

Easy ___ Hard ___

4. Do you think science is exciting or boring?

Exciting ___ Boring ___

5. Do you think science lessons are exciting or boring?

Exciting ___ Boring ___

6. Rank subjects in order of interest, starting with your favourite

7. Make a tick where you think the following subjects are more suitable for girls, boys or both?

Subject	Boys	Girls	Both
English	—	—	—
French	—	—	—
German	—	—	—
Technology	—	—	—
Maths	—	—	—
Music	—	—	—
PE	—	—	—
Science	—	—	—
Humanities	—	—	—

8. Do you think science will be useful for you when you go to work?

Yes __ No __ Don't know __

9. What sort of jobs do you think science is necessary for?

10. Please fill in the attached sheet following the instructions at the top.

Thank you for filling in this questionnaire, we will talk about these questions in our interview.

G.Sharp 1994

Background activity A.

Have you ever used any of these things yourself? Put a tick in the first column by the ones you have used at school. Put a tick in the second column by the ones you have used at home or out of school.

	at school	at home or out-of- school
a hand lens (magnifying glass)	—	—
a thermometer	—	—
a stop watch or stop clock	—	—
a spring balance	—	—
a computer to play games	—	—
a computer to do things besides playing games	—	—
a dropper	—	—
a compass	—	—
metre stick	—	—
a measuring cylinder or jug	—	—
a screwdriver	—	—
weighing scales	—	—
a microscope	—	—

Appendix 5

Interview Sheet Year 7 pupils

Q.1 What parts of science lessons do you like best? Why?

Q.2 How could science be made better?

Q.3 Do you have whole class discussion at the beginning of a lesson? If so do you like it? What is their perception of who takes up most space? Why do you think teachers do it? Do you have whole class discussion at the end of the lesson? If so do you like it? Why do you think teachers do it?

Q.4 Which things are you good at in science? Why do you think you are good at those things?

Q.5 On a scale of 1-5 how good do you think you are at Science? (1 is excellent, 5 poor).

Q.6 Are some things you do in science easy? Give me some examples.

Q.7 Are there some things in science you find hard? What are they?

Q.8 Are there any bits of science you find exciting?

Q.9 Which bits of science do you find boring?

Q.10 Compared with other subjects where does science fit in and why?

Why are other subjects more interesting?

Q.11 What sorts of things do you do out of school? Do you think what you do out of school affects your learning in science?

Is there anything else that affects your learning in science?

Q.12 What jobs do you think scientists do?

Q.13 What do you expect to get out of science?

Q.14 Is science important to you?

Q.15 Do your parents like science?

Q.16 Do you think boys or girls are better at certain parts of science lessons? If so which?

Q.17 Do you think that science is aimed at boys or girls in particular?

Q.18 What do you think about CASE?

Appendix 6

Year 7 and 8 survey response to questions 1 to 20

In Year 7 responses to 1 and 2 were merged for questions 1-7, 9, 10, 12, 14, 19 and 20 because the number of responses were separately too small to ensure the reliability of the chi-squared test.

Questions 8, 11, 13, 15, 16, 17 and 18 were analysed without any merging of categories. The chi-squared test was used at significance levels of $p < .01$, $p < .001$ and $p < .0001$.

Table 6.1. Year 7 and 8 responses to survey questions 1 - 20 indicating statistically significant differences.

Question	Gender difference Year 7	Gender difference Year 8
Q. 1 How well do you think you will do in science?	-	-
Q. 2 Do you think you are good at science?	**** b>g	*** b>g
Q. 3 Do you think you are good at problem solving?	*** b>g	** b>g
Q. 4 Do you think you are good at explaining what you have found out?	-	-
Q. 5 Do you think you are good at practical work?	-	-
Q. 6 Are you good at writing up what you have done?	-	-
Q. 7 Are you active in small group discussions?	-	-
Q. 8 Are you active in whole class discussions?	-	-
Q. 9 Do you like working in small groups?	-	-
Q. 10 Do you like doing practical work?	-	-
Q. 11 Do you like writing about what you have done?	-	-
Q. 12 Do you like being active in small group discussions?	-	-
Q. 13 Do you like whole class discussions?	-	-
Q. 14 Do you like using the Bunsen burner?	-	-
Q. 15 Do you like asking for help in practical work?	-	-
Q. 16 Do you like asking for help with written work?	-	-
Q. 17 Do you like explaining what you have found out?	-	-
Q. 18 Do you like problem solving?	*** b>g	** b>g
Q. 19 Do you like making up your own experiments?	-	** b>g
Q. 20 Do you like science?	-	-

Key: b>g more positive responses from boys than girls; g>b more positive responses from girls than boys; ** $p < .01$; *** $p < .001$; **** $p < .0001$; - no statistically significant difference.

Appendix 7

Topic preferences

Table 7.1. Topic preferences for year 7 pupils surveyed by gender (number of responses)

<u>girls</u>		<u>boys</u>	
animals	81	electricity	54
human body	64	human body	45
food	59	acids/alkalis	40
health	59	space	39
electricity	59	animals	37
environment	50	food	33
materials	45	magnetism	32
plants	41	energy	30
space	41	forces	29
acids and alkalis	37	microbes	28
separating	35	health	28
magnetism	32	materials	28
energy	28	plants	24
microbes	24	separating	22
measuring	16	environment	18
forces	10	measuring	18
<u>Total choices</u>	<u>627</u>		<u>505</u>

(n= 75 boys, n=133 girls)

Table 7.2. Topic preferences for year 8 pupils surveyed by gender (number of responses)

<u>girls</u>		<u>boys</u>	
materials	101	electricity	54
animals	87	environment	51
magnetism	69	materials	45
environment	68	acids and alkalis	45
plants	66	measuring	38
food	64	magnetism	36
space	63	human body	35
acids and alkalis	61	forces	33
electricity	58	separating	30
separating	55	health	25
forces	54	space	21
microbes	51	animals	20
health	40	microbes	17
human body	38	food	16
measuring	35	plants	13
energy	12	energy	5
<u>Total choices</u>	<u>922</u>		<u>453</u>

(n=60 boys, n= 127 girls).

Table 7.3. Year 7 percentage response topic preference.

Topic preference	% response girls	% response boys
acid/alkali	28	53
microbes	18	37
forces	8	39
environment	38	24
human body	48	60
energy	21	40
plants	31	32
health	44	37
materials	34	37
space	31	52
measuring	12	24
separating things	26	29
food	44	44
magnetism	24	43
animals	61	49
electricity	44	72

Table 7.3 indicates in bold that 50% or more year 7 girls selected only one topic: animals. Whereas 50% or more boys selected 4 topics: electricity; human body; acids and alkalis; space.

Table 7.4. Year 8 percentage response topic preference.

topic preference	% response girls	% response boys
acid/alkali	48	75
microbes	40	28
forces	43	55
environment	54	85
human body	30	58
energy	9	8
plants	52	22
health	31	42
materials	80	75
space	50	36
measuring	28	63
separating things	43	50
food	50	27
magnetism	54	60
animals	69	33
electricity	46	90

Table 7.4 indicates in bold that 50% or more year 8 girls selected seven topics: space, animals; materials; magnetism; environment; plants; food, whereas 50% or more boys selected nine topics:

electricity; environment; acids and alkalis; materials; measuring; magnetism; human body; forces;
separating things.

Appendix 8

Year 7 and 8 survey response to questions 21 to 25

Q.21 Do you prefer working with friends in science group work? yes no don't know

Q.22 Do you think science is a boys subject? yes no don't know

Q. 23 Do you think science is a girls subject? yes no don't know

Q.24 Do you think science is exciting? yes no don't know

Q.25 Do you think science is boring? yes no don't know

Table 8.1. Year 7 percentage pupils' responses to questions 21 - 25, by gender

	Girls' positive response %	Girls' don't know response %	Girls' negative response %	Boys' positive response %	Boys' don't know response %	Boys' negative response %
Q 21	90	7	3	91	3	7
Q 22	9	8	83	8	15	77
Q 23	14	14	73	8	15	77
Q 24	71	19	11	79	12	9
Q 25	10	15	75	16	12	72

Total number of girls =133, boys =75 in 1994.

Table 8.2. Year 8 percentage pupils' responses to question 21 - 25, by gender.

	Girls' positive response %	Girls' don't know response %	Girls' negative response %	Boys' positive response %	Boys' don't know response %	Boys' negative response %
Q 21	89	5	2	92	3	5
Q 22	4	10	82	10	8	82
Q 23	6	11	78	8	10	82
Q 24	53	29	14	77	5	18
Q 25	10	19	67	5	23	72

Total number of girls =125, boys = 60 in 1995.

Appendix 9

Pre interview questionnaire background activities data

Table 9.1 illustrates the number of positive responses, by gender, for Year 7 pupils.

Activity A	at school girls		at school boys		at home or out of school girls		at home or out of school boys	
	a	b	a	b	a	b	a	b
used a hand lens	29	72.5	19	95	17	42.5	13	65
used a thermometer	29	72.5	20	100	22	55	12	60
used a stop watch or clock	30	75	20	100	20	50	16	80
used a spring balance	30	75	19	95	1	2.5	3	15
used a computer to play games	12	30	12	60	29	72.5	19	95
used a computer to do things other than play games	23	57.5	19	95	18	45	13	65
used a dropper	27	67.5	15	75	6	15	3	15
used a compass	27	67.5	16	80	20	50	17	85
used a metre stick	29	72.5	19	95	5	12.5	9	45
used a measuring cylinder	29	72.5	20	100	26	65	12	60
used a screwdriver	17	42.5	13	65	19	47.5	16	80
used weighing scales	26	65	19	95	29	72.5	18	90
used a microscope	27	67.5	20	100	9	22.5	7	35

column a = actual responses, column b = percentage responses

Table 9.2 illustrates the number of positive responses for Year 8 pupils to activities A.

Activity A	at school girls		at school boys		at home or out of school girls		at home or out of school boys	
	a	b	a	b	a	b	a	b
used a hand lens	38	95	18	90	21	52.5	12	60
used a thermometer	37	92.5	18	90	27	67.5	10	50
used a stop watch or clock	39	97.5	17	85	25	62.5	15	75
used a spring balance	38	95	16	80	2	5	3	15
used a computer to play games	14	35	11	55	37	92.5	18	90
used a computer to do things other than play games	33	82.5	16	80	21	52.5	15	75
used a dropper	34	85	15	75	9	22.5	4	20
used a compass	33	82.5	14	70	20	50	14	70
used a metre stick	37	92.5	17	85	8	20	6	30
used a measuring cylinder	36	90	15	75	31	77.5	13	65
used a screwdriver	22	55	11	55	33	82.5	17	85
used weighing scales	31	77.5	17	85	37	92.5	17	85
used a microscope	33	82.5	18	90	12	30	7	35

column a = actual responses, column b = percentage responses

Appendix 10

Interview Sheet Year 9 pupils

- Q.1 What parts of science lessons do you like best? Why?
- Q.2 How could science lessons be made better?
- Q.3 Are you good at science? Does your teacher think so?
- Q.4 On a scale of 1-5 how good do you think you are at Science? (1 is excellent and 5 is poor).
- Q.5 Which things are you good at in science? Why do you think you are good at those things?
- Q.6 Are some things you do in science easy? Give me some examples.
- Q.7 Are there some things in science you find hard? What are they?
- Q.8 Are there any bits of science you find exciting?
- Q.9 Which bits of science do you find boring?
- Q.10 Compared with other subjects where does science fit in and why? Why are other subjects more interesting?
- Q.11 Why do you learn science do you think?
- Q.12 Is science important to you?
- Q.13 Do you think boys and girls are equally as able to do science? Can you say why you think this is?
- Q.14 Do you think that science is more for boys or girls in particular?
- Q.15 What do you plan to do after year 11?
- Q.16 If you are staying on at school what subjects will you choose, what level and why?
- Q.17 If you could drop science at the end of this year, would you? If so, why?

Appendix 11

Year 10 pre interview questionnaire

1. (i) How do you feel at the start of your GCSE examination courses -all subjects? (do you feel confident, apprehensive, excited, worried, etc)?
- (ii) What about science (do you feel confident, apprehensive, excited, worried, etc)-what science course are you doing - dual science or three separate sciences?
2. (i) Any positive factors about Double Award science or biology, physics and chemistry- this could be about the content, your interest, the teaching, the practical work, etc?
- (ii) Any negative factors about Double Award science or biology, physics and chemistry-?
- (iii) Any positive factors about non- - science courses this could be about the content, your interest, the teaching, the practical work, etc?
- (iv) Any negative factors about non- - science courses
3. What do you expect to achieve in terms of your understanding, knowledge, qualifications, help and choices at 16+?
- (i) In terms of grades for biology, physics and chemistry or dual science at the final exam stage?
- (ii) In terms of grades for non-science subjects at the final exam stage?
- (iii) By completing the course of study in dual science or the three separate sciences?
- (iv) From your coursework in dual science or the three separate sciences?

4. (i) What are your views about the coursework (this includes homework), both assessed and non-assessed, you have to do in non-science subjects? - any positive factors or negative ones?
- (ii) What are your views about the coursework (this includes homework), both assessed and non-assessed, you have to do in Double Award science or physics chemistry and biology? - any positive factors or negative ones?
5. What are your thoughts about the GCSE exams in all subjects? Do you feel confident that you will be successful?
6. What are your thoughts about the GCSE exams in Double Award science or in physics, chemistry and biology? Do you feel that you will be successful?
7. (i) What is the workload for GCSE like generally?
- (ii) What is the workload like in Double Award science or in physics, chemistry and biology compared with other subjects?
8. Have you understood the work that you have completed so far in Double Award science or in physics, chemistry and biology?
9. Do you have the same teacher for all of your dual science lessons or for all three sciences?
- 10 (i) What sort of relationship do you have with your non-science teacher(s)? Do you find that the teacher is supportive, explains things well, makes you work hard, gives you too much homework, is fair, is understanding when you have difficulties, etc?

- (ii) What sort of relationship do you have with your science teacher(s)? Do you find that the teacher is supportive, explains things well, makes you work hard, gives you too much homework, is fair, is understanding when you have difficulties, etc.
11. Have you had your science teacher before in year 7, 8 or 9?
- 12(i) How are you doing (this question is referring to your success both at a personal level-do you feel that you are understanding the content, trying hard in the subject, achieving good marks, etc) in other non-science subjects?
- (ii) How are you doing (this question is referring to your success both at a personal level-do you feel that you are understanding the content, trying hard in the subject, achieving good marks, etc) in Double Award science or physics chemistry and biology?
13. (i) Do you feel that work you completed in year 7, 8 and 9 has aided your understanding in Year 10 in non-science subjects?
- (ii) Do you feel that work you completed in year 7, 8 and 9 has aided your understanding in Year 10 in dual science or physics chemistry and biology?
14. (i) Do you wish to be successful (achieve good coursework grades, understand what you are doing, achieve good mock and final exam grades, enjoy what you are doing) in non - science subjects?
- (ii) Do you wish to be successful (achieve good coursework grades, understand what you are doing, achieve good mock and final exam grades, enjoy what you are doing) in Double Award science or physics chemistry and biology?

15. (i) Reflect for a moment and suggest what is motivating you to do well (it could be personal satisfaction, getting a good qualification, parental expectation, wanting to do well for the teacher, wanting to understand the work so that you can do A level and maybe go to university, etc.) in non- science subjects:
- (ii) Reflect for a moment and suggest what is motivating you to do well (it could be personal satisfaction, getting a good qualification, parental expectation, wanting to do well for the teacher, wanting to understand the work so that you can do A level and maybe go to university, getting good marks for the school, etc.) in science subjects.

Bibliographical References

Aikenhead, G. and Jegede, O. (1999). Cross-cultural Science Education: A Cognitive explanation of a Cultural Phenomenon. Journal of Research in Science Teaching Vol. 36, 3: pp.269-287.

Aikenhead, G. and Solomon, J. (1994). Knowledge, values and the Public Choice of Science Knowledge.

STS Education: International Perspectives on Reform. New York. Teachers College Press.

Alloway, N. (1995) Foundation Stones. The construction of gender in early childhood. Carlton, Vic.

Curriculum Corporation.

Allport, G.W. (1954). Attitudes. In Fishbein, M. (1967) (Ed.) Readings in Attitude Theory and

Measurement. New York. Wiley.

Andersen, A.M. and Sørensen, H. (1995) Action Research and Teacher development in Denmark-toward a gender inclusive classroom. Paper presented at European Science Education Research Association (ESERA) conference. Leeds. April 1995.

Archer, J. (1992). Gender Stereotyping of School Subjects The Psychologist: Bulletin of the British Psychological Society Vol. 5, pp. 66-69.

Arnot, M., Gray, J., Rudduck, J. and Duveen, G. (1998) Recent Research on Gender and Educational Performance. (Ofsted Reviews of Research). London. HMSO.

Association for Science Education (ASE) (1979). Alternatives for Science Education: Consultative Document. Hatfield. ASE.

Bailey, V. (1992). Student Non-completion of BTEC Programmes and Awards. Internal Report. London. BTEC.

Barr, J. (1990). Liberating Knowledge: Research, feminism and adult education. Leicester. NIACE.

Baumert, J. (1995). Gender, science interest, teaching strategies and socially shared beliefs on gender roles. Paper presented at the Annual Meeting of the American Educational Research Association. San Francisco.

Becker, H.S. (1970). Sociological Work. Method and Substance. Chicago. Aldine.

Belenky, M.F., Clinchy, B.M., Goldberger, N.R. and Tarule, J.M. (1986) Women's Ways of Knowing: The development of self, voice and mind. New York. Basic books.

Bell, J. (1987). Doing your research project. A Guide for first time researchers in education and social science. Milton Keynes. Open University Press.

Bentley, D. and Watts, M. (1986). Courting the positive virtues: a case for feminist science. European Journal of Science Education. Vol. 8, 2: pp.121-134.

Beyer, K. (1992). Project organized university studies in science: Gender, metacognition and quality of learning. Paper presented at the 2nd European GASAT conference, Eindhoven, The Netherlands. (July, 1992).

- Beyer, K. and Reich, J. (1987). Why are so many girls inhibited from learning scientific concepts in physics? In contributions to the Fourth International GASAT conference. USA. Michigan. Ann Arbor. (July, 1992).
- Biklen, S.K. and Bogdan, R.C. (1982). Qualitative Research for Education: An Introduction to Theory and Methods. Boston Mass. Allyn and Bacon.
- Birke, L. (1986) Women, Feminism and Biology: the feminist challenge. Brighton. Wheatsheaf.
- Black, P. (1993) The Purposes of Science Education. In Whitelegg, E., Thomas, J. and Tresman, S. Challenges and Opportunities for Science Education. London. Paul Chapman and Open University.
- Black, P. and William, D. (1998). Inside the Black Box. Raising Standards through classroom assessment. King's College, London.
- Bleach, K. (1998). Raising Boys' Achievement in Schools. Stoke on Trent. Trentham Books.
- Bloom, B.S. (1976). Human characteristics and school learning. New York. McGraw.
- Boaler, J. (1998). Mathematical equity - underachieving boys or sacrificial girls. International Journal of Inclusive Education. Vol. 2, 2: pp.19-134.

Bottomley, J. (1979). A longitudinal study from middle school to 14 years of some factors affecting the development and stability of English pupils' interest in science and their science subject choice. PhD thesis. Uxbridge. Department of Education, Brunel University.

Branden, N. (1994) The six pillars of self-esteem. New York. Bantam.

Browne, N. and Ross, C. (1991). Girls' stuff, boys' stuff: young children talking and playing. In Browne, N. (Ed.) Science and technology in the Early Years. Milton Keynes. Open University Press.

Bruner, J. (1986). Actual minds. Possible Worlds. Cambridge, MA. Harvard University Press.

Bruner, J. (1987). Life as narrative. Social Research Vol.54, pp.11-32.

Bruner, J. (1989). The Transactional Self. In Murphy, P. and Moon, B, (Eds.) Developments in Learning and Assessment. London. Hodder and Stoughton.

Bruner, J. (1996). The Culture of Education. Cambridge, MA. Harvard University Press.

Business and Technology Education Council (BTEC) Annual Reports. 1988, 1992. London. BTEC.

Burgess, R.G. (1984). In the Field: an introduction to field research. London. George Allen & Unwin.

Byanyima, W (1994) The role of women engineers in developing countries. RSA Journal Vol. 142, 5454 pp. 57-66.

- Byrne, B.M. (1984). The general/academic self-concept nomological network: a review of construct validation research. Developmental Psychology. Vol. 18, pp. 427-456.
- Byrne, E. M. (1993). Women and Science: the Snark Syndrome. London. The Falmer Press.
- Cannon, R.K. and Simpson, R.D. (1985). Relationship among attitude, motivation and achievement ability grouping in 7th grade life science students. Science Education. Vol. 69, 2: pp.121-138
- Carré, C. (1981). Language, Teaching and Learning: Science. London. Ward Lock.
- Cerini, B., Murray, I. And Reiss, M. (2003) Student Review of the Science Curriculum. Major Findings. London. Generation Press.
- Chambers, D.W. (1983). Stereotypic images of the Scientist: the Draw a Scientist Test. Science Education Vol. 67, pp. 255-265.
- Cheng, Y., Payne, J. and Witherspoon, S. (1995). Science and Mathematics in full time education after 16. London. Youth Cohort Report No 36, DfEE.
- Chodorow, N.J. (1978). The reproduction of mothering: Psychoanalysis and the socialisation of gender. Berkeley. University of California Press.
- Clarricoates, K. (1987). Dinosaurs in the Classroom. In Weiner, G. and Arnot, M. (Eds.) Gender and the Politics of Schooling. London. Huthchinson.
- Claxton, G. (1997). Science of the Times. A 2020 vision of education. Science Today. In Levinson, R. and Thomas, J. (Eds.) Science Today, Problem or crisis? London. Routledge.

Collings, J. and Smithers, A (1984). Person Orientation and Science Choice. European Journal of Science Education. Vol. 6, 1: 55-65

Comber, L.C. and Keeves, J.P. (1973). Science in 19 countries: an empirical study. London. John Wiley&Sons.

Cook, J. (1996). Negotiating the curriculum: Programming for learning. Negotiating the Curriculum: Educating for the 21st century. London. Falmer Press.

Craig, J. and Ayers, D.G. (1988). Does Primary Science affect Girls' and Boys' Interest in Secondary Science? School Science Review. Vol. 69, 248: pp. 417-426.

Crossman, M. (1987). Teacher's interaction with girls and boys in science lessons. In

Kelly, A. (Ed.) Science for Girls. Milton Keynes. Open University Press.

Dale, R., Bowe, R. et al. (1990). The TVEI story. Milton Keynes. Open University Press.

Davies, B. (1989) Frogs and Snails and Feminist Tales. London. Allen Unwin.

Davies, J. and Brember, I. (1994). Attitudes to School and the Curriculum in year 2 and year 4: Changes over Two Years Educational Review Vol. 47, 1.

Davies, J. and Brember, I. (1996). Attitudes to School and the Curriculum in year 2, year 4 and year 6: Changes over Four Years. School of Education, University of Manchester.

Dearing Report (1993). The National Curriculum and its Assessment - Final Report (The Dearing Report). London. School Curriculum and Assessment Authority.

- Delamont, S. (1981). All too familiar? A decade of classroom research. Education Analysis, Vol. 3, 1: pp. 69-83.
- Delamont, S. (1990). Sex Roles and the School. Second Edition. London. Routledge.
- Delamont, S. and Galton, M. (1986). Inside the Secondary Classroom. London. Routledge & Kegan Paul.
- Denzin, N.K. (1989). Interpretive interactionism. Newbury Park, California. Sage.
- Denzin, N. K. and Lincoln, Y.S. (1994) (Eds.) Handbook of Qualitative Research. Thousand Oaks. Sage.
- Department for Education and Science (DES) Sex Discrimination Act (1975). London. HMSO.
- DES (1977). Education in Schools. London. HMSO.
- DES (1978). Statistics of Education. School Leavers. 1978 CSE and GCE. Volume 2, England. London. HMSO.
- DES (1980). Girls and Science. HMI series: Matters for discussion 13. London. HMSO.
- DES (1980a). A framework for the School Curriculum. London. HMSO
- DES (1981). The School Curriculum. London. HMSO.
- DES (1982). Science in Schools. Age 15: APU Report No. 1. London. HMSO.
- DES (1982). Statistics of Education. School Leavers CSE and GCE, England. London. HMSO.

- DES (1983). Statistics of Education. School Leavers CSE and GCE, England. London. HMSO.
- DES (1984). Statistics of Education. School Leavers CSE and GCE, England. London. HMSO.
- DES (1985). Science 5-16: A statement of policy. London. HMSO.
- DES (1985). Statistics of Education. School Leavers CSE and GCE, England. London. HMSO.
- DES (1987). The National Curriculum 5 - 16. A consultation document. London. HMSO.
- DES (1988). Statistics of Education. School Leavers CSE and GCE, England. London. HMSO.
- DES (1988a). Science at age 15-A review of APU Survey Findings. London. HMSO.
- DES (1988b). A Report. National Curriculum Task Group on Assessment and Testing. London. HMSO.
- DES (1989a). Science In Schools Age 11: APU Review Report. London. HMSO.
- DES (1989b). Science In Schools Age 13:APU Review Report. London. HMSO.
- DfEE (1992). Statistics of Education. School Leavers GCSE and GCE, England. London. HMSO.
- DfEE (1993). Statistics of Education. School Examinations. GCSE and GCE, England. London. HMSO.
- Dewey, J. (1926). Democracy and education. New York, Macmillan.
- Dewey, J. (1929). The quest for certainty. New York. Putnam.

- Dewey, J. (1933). How we think: a restatement of the relation of reflective thinking to the educative process. Boston. Heath.
- Dewey, J. (1963). Experience and Education. London, Collier Macmillan (*originally published 1938*).
- Driver, R. Head, J and Johnson, S. (1984). The uptake of science in schools in England and Wales and Northern Ireland. European Journal of Science Education. Vol. 6, 1: pp.19-29.
- Driver, R and Oldham, V. (1986). *A Constructivist Approach to Curriculum Development in Science*. Studies in Science Education. Vol. 13, pp.105-122.
- Driver, R., Leach, J., Millar, R. and Scott, P. (1996). Young People's Images of Science. Buckingham. Open University Press.
- Duvcan, G. and Lloyd, B. (1986) The significance of social identities. British Journal of Educational Psychology. Vol. 25, pp.219-30.
- Dweck, C., Davidson, W., Nelson, S. and Enna, B (1978). Sex Differences in Learned Helplessness: II. The contingencies of evaluative feedback in the classroom and III. An experimental analysis. Developmental Psychology. Vol. 14: pp.268-76.
- Dworkin, M. (1959). Dewey on Education. New York. Teachers College Press.
- Elwood, J. and Comber, C. (1996). Gender Differences in Examinations at 18+. Final report Institute of Education. University of London, Institute of Education and University of Leicester, School of Education.
- Elwood, J. and Murphy, P. (2002) Tests, Tiers and Achievement: gender and performance at 16 and 14 in England. European Journal of Education. Vol. 37, 4: pp.395- 416.

- Equal Opportunities Commission (1985). The response of the EOC to the DES discussion document: the organisation and content of the 5-16 curriculum. Manchester. EOC.
- Erickson, G.L. and Erickson, L.J. (1984). Females and Science Achievement; Evidence, Explanations and Implications. Science Education. Vol. 68, pp. 63-89.
- Fairweather, H. (1976). Sex Differences in Cognition. Cognition Vol. 4, 3: pp. 231-280.
- Faulkner, J. (1991). Mixed sex schooling and equal opportunity for girls: a contradiction in terms? Research Papers in Education. Vol. 6, 3:pp.197-223.
- Fennema, E. and Tartre, L.A. (1985). The use of spatial visualisation in maths by girls and boys. Journal of Research in Mathematics Education. Vol. 16, pp.184-206.
- Fensham, P. (1993). Reflections on science education for all. In Whitelegg, E., Thomas, J. and Tresman, S. (Eds.) Challenges and Opportunities for Science Education. London. Open University and Paul Chapman.
- Firestone, W. (1987). Meaning in method: the rhetoric of quantitative and qualitative research. Educational Researcher. Vol. 16, pp.16-21.
- Fisher, J. (1994). The case for girls-only schools. Education Review Vol. 8, 2: pp.49-50.
- Fitz-Gibbon, C. T. and Vincent, L. (1994). Candidates' Performance in Public Examinations in Mathematics and Science. London. Schools Curriculum and Assessment Authority.
- Fivush, R. (1998). Interest, gender and personal narrative: how children construct self-understanding. Interest and Learning. Kiel, University of Kiel.

- Flam, F. (1991). Still a "chilly climate" for women. Science Vol. 252, pp. 1604 -1606.
- Fontana, A. and Frey, J. H. (1994). Interviewing: The Art of Science. In Denzin, N.K. and Lincoln, Y.S. (Eds.) Handbook of Qualitative Research. Thousand Oaks. Sage.
- Fraser, B.J. (1982). How are attitudes and achievement related? School Science Review. Vol. 63, 224: pp. 557-559.
- Galton, M. (1981). Differential treatment of boys and girl pupils during science lessons. In Kelly, A. (Ed.) The Missing Half. Manchester University Press.
- Galton, M. and Eggleston, J. (1979). Some characteristics of effective science teaching. European Journal for Science Education. Vol. 1, pp.75.
- Gardner, P.L. (1974). Sex Differences in Achievement, Attitude and Personality of Science Students. Science Education Research. Vol. pp.231-158.
- Gardner, P.L. (1975). Attitudes to Science: a review. Studies in Science Education. Vol. 2, pp.1-41.
- Gardner, P.L. (1987). Measuring ambivalence to science. Journal of Research in Science Teaching Vol. 24, pp.241-247.
- | | |
|---|---|
| <u>GASAT International conference proceedings</u> | 1 st 1981 Eindhoven, The Netherlands. (September, 1981). |
| <u>GASAT International conference proceedings</u> | 2 nd 1983. Gran, Norway. (September, 1983). |
| <u>GASAT International conference proceedings</u> | 3 rd 1985 Chelsea College, London. (April, 1985) |
| <u>GASAT International conference proceedings</u> | 4 th 1987 Michigan, USA. Ann Arbor. (July, 1987) |

- GASAT International conference proceedings 5th 1989 Haifa, Israel. July, (1989)
- GASAT International conference proceedings 6th 1991 Melbourne, Australia. (July, 1991).
- GASAT International conference proceedings 7th 1993 Waterloo, Ontario. (July, 1993).
- Gaskell, J. and Hildebrand, G. (1996). Teaching Individuals in a Gendered World. Reflect: The Journal of Reflection in Learning and Teaching. Hawker Brownlow Education, Australia. Vol. 2, 2:pp.36-42.
- Gauld, C.F. and Hukins, A.A. (1980). Scientific attitudes - a review. Studies in Science Education, Vol. 7, pp. 129 - 161.
- German, P.J. (1988). Development of the Attitude Towards Science in School Assessment and its use to Investigate the relation between science achievement and attitudes toward science in schools. Journal of Research in Science and Technology. Vol. 25, 8: pp. 689-703.
- Gianello, L. (1988). (Ed.) Getting into gear: gender inclusive teaching strategies in science developed by the McClintock Collective. Canberra. CDC.
- Gilbert, J. and McComish, J. (1990). Science Learning, Language and Feminist Pedagogy. SAME papers. 1990. Science and Mathematics Education papers. Begg, A., Bell, B., Biddulph, F., Carr, M., McChesney, J. and Jenny Young Loveridge (Eds.) Centre for Science and Mathematics Education Research, University of Waikato, Hamilton, New Zealand. Longman Paul.
- Gillborn, D. and Gipps, C. (1996). Recent Research on the Achievement of Ethnic Minority Pupils Office for Standards in Education. Institute of Education. London. HMSO.
- Gilligan, C. (1982). In a different voice: Psychological Theory and women's development. Cambridge, MA. Harvard University Press.
- Gipps, C. (1994). Beyond testing: Towards a theory of educational assessment. London. The Falmer Press.

- Gipps, C. (1996). Review and Conclusions: A Pedagogy or a Range of Pedagogic Strategies? In Gipps, C. and Murphy, P.F. (Eds.) Equity in the Classroom, London/Paris. Falmer/Unesco.
- Gipps, C. and Murphy, P. (1994). A Fair Test? Assessment, Achievement and Equity. Buckingham. Open University Press.
- Gott, R., Davey, A., Gamble, R., Head, J., Khalig, N., Murphy, P., Orgee, T., Schofield, B. and Welford, G. (1985). Assessment Performance Unit Science in Schools: ages 13 and 15: Report No. 3. London. HMSO.
- Grafton, T., Miller, H., Smith, L., Vegoda, M. and Whitfield, R. (1987). Gender and curriculum choice. In Arnot, M. and Weiner, G. (Eds.) Gender and the Politics of Schooling. London. Hutchinson.
- Habermas, J. (1972). Knowledge and human interests. Second edition. London. Heinemann.
- Hacker, R.G. and Rowe, M.J. (1997). The Impact of a National Curriculum development on teaching and learning behaviours. International Journal of Science Education. Vol. 19, 9: pp. 997-1004.
- Hadden and Johnstone (1983). Primary school children's attitudes to science: the years of formation, European Journal of Science Education Vol. 5, 3: pp. 397-407.
- Haladyna, T. and Saughnessy, J. (1982). Attitudes Towards Science: a Quantitative Synthesis. Science Education. Vol. 66, 4: pp. 574-563.
- Haladyna, T. and Saughnessy, J. (1983). Correlates of Attitudes Towards Science. Journal of Research in Science and Technology. Vol.20, 4: pp. 311-324.
- Halpern, D.F. (1992). Sex differences in cognitive abilities Hillsdale: Lawrence Erlbaum Associates Inc.

- Hammersley, M. (1990). Classroom Ethnography. Milton Keynes. Open University Press.
- Hammersley, M. (1992). What's wrong with ethnography? Methodological explorations. London. Routledge.
- Hammersley, M., Gomm, R. and Woods, P. (1994). Educational Research Methods: Study Guide E 824. Milton Keynes. Open University Press.
- Hannover, B. (1998). The development of self-concept and interests. In Hoffmann, L., Krapp, A., Renninger, K and Baumert, J. (Eds.) Interest and Learning. Kiel. University of Kiel Press.
- Harding, J. (1979). Sex Differences in Performance in Examinations at 16+. Physics Education Vol. 14, pp. 280-284.
- Harding, J. (1983). Switched Off: The Science Education of Girls. New York. Longman.
- Harding, J. (1986a). (Ed.) Perspectives on Gender and Science. Lewes. The Falmer Press.
- Harding, J. (1996). Girls' Achievement in Science and Technology -implications for pedagogy. In Gipps, C. and Murphy, P. (Eds.) Equity in the Classroom: Towards an Effective Pedagogy for Girls and Boys. London/Paris. Falmer Press/UNESCO.
- Harding, S. (1986). The science question in feminism. New York. Cornell University Press.
- Harding, S. (1987). (Ed.) Feminism and methodology. Milton Keynes. Indiana University Press and Open University Press.

- Harlen, W. (1992). The Teaching of Science: Studies in Primary Education. London. David Fulton.
- Harvey T.J. and Stables, A. (1986). *Gender differences in attitudes to science for third year pupils: an argument for single sex teaching in mixed schools.* Research in Science and Technological Education. Vol. 4, pp.163-170.
- Head, J.O. (1985). The Personal Response to Science. Cambridge University Press.
- Head, J.O. (1989). The Affective Constraints on Learning Science. In Adey, P., Bliss, J., Head, J. and Shayer, M. (Eds.) Adolescent Development and School Science. London. Falmer Press.
- Head, J.O. (1996). Gender Identity and Cognitive Style. In Gipps, C. and Murphy, P.F. (Eds.) Equity in the Classroom. London/Paris. Falmer/UNESCO.
- Head, J.O. and Ramsden, J. (1990). Gender psychological type and science. International Journal of Science Education. Vol. 12, pp. 115-21.
- Hendley, D, Stables, A., Parkinson, J. and Tanner, H. (1995) *Gender differences in pupil attitudes to the National Curriculum foundation subjects of English, maths, science and technology in Key Stage 3 in South Wales.* Educational Studies. Vol. 21, pp. 85-89.
- Her Majesty's Inspectorate (1979). Aspects of Secondary Education in England. London. HMSO.
- Her Majesty's Inspectorate (1980). A View of the Curriculum London. HMSO.
- Her Majesty's Inspectors of Schools (1994). Effective Learning and Teaching in Scottish Secondary Schools: The Sciences. Edinburgh: The Scottish Office Education Department.

- Hildebrand, G. (1985) Gazing to the Future. In proceedings for the 3rd GASAT International conference Chelsea College, London. (April, 1985).
- Hildebrand, G. (1996). Redefining Achievement. In Gipps, C. and Murphy, P.F. (Eds.) Equity in the Classroom: Towards an effective pedagogy for girls and boys. London/Paris. Falmer/UNESCO.
- Hildebrand, G. and Dick, B. (1990). Innovative Science Classroom Practices. In Contributions to the First European GASAT conference. Jonkoping, Sweden. (July, 1990).
- Hitchcock, G., and Hughes, D. (1989). Research and the Teacher. A qualitative introduction to school based research. Routledge. London and New York.
- Hodson, D. (1993). Teaching and Learning about science: considerations in the philosophy and sociology of science. In Edwards, D., Scanlon, E. and West, D. (Eds.) Teaching, Learning and Assessment in Science Education. London. Open University and Paul Chapman.
- Hoffmann, L. and Haussler, P. (1998). Qualitative differences in Students' Interest in Physics and the Dependence on Gender and age. In Hoffmann, L., Krapp, A., Renninger, K.A. and Baumert, J. (Eds.) Interest and Learning. Proceedings of the Seeon Conference on Interest and Gender. Kiel.
- Holland, J. and Blair, M with Sheldon, S. (1995). (Eds.) Debates and Issues in Feminist Research and Pedagogy. Milton Keynes. Open University Press.
- Home Office (1975). A Guide to the Sex Discrimination Act. 1975. HMSO, London.
- Hopkins, D. (1985). A Teachers Guide to Classroom Research. Milton Keynes. Open University Press.

- Hovland, C., Irving, L., and Kelly, J and H (1963). Communication and Persuasion: psychological studies of opinion change. New Haven. Yale.
- Hueftle, S.J., Rakow, S.J. and Welch, W.W. (1983). Images of Science: a summary of results from the 1981-1982 National Assessment in Science. Minneapolis. Minnesota Research and Evaluation Center. University of Minnesota.
- Hutt, C. (1972a). Males and Females. London. Penguin.
- Hutt, C. (1972b). Sex Differences in Human Development. Human Development. Vol. 15:pp.153-70.
- Hyde, J. (1981). How large are cognitive gender differences? American Psychologist Vol. 36, 8: pp. 892-901.
- Hyde, J., Fennema, E. and Lamon, S.J. (1990). Gender differences in maths performance: a meta analysis. Psychological Bulletin. Vol. 107, pp. 139-155.
- International Association for the Evaluation of Educational Achievement (IEA) (1988). Science Achievement in Seventeen Countries: a preliminary report. Oxford. Pergamon Press.
- Jarvis, T. (1996). Examining and extending young children's views of science and scientists. In Parker, L., Rennie, L. and Fraser, B. (Eds.) Gender, Science and Mathematics: shortening the shadow. Dordrecht, Boston, London. Kluwer Academic publishers.
- Johnson, S. and Murphy, P. (1986). Girls and Physics. (Assessment Performance Unit Occasional Paper No. 4). London. DES.

- Johnson, S. (1987). Gender Differences in Science: parallels in interest, experience and performance. International Journal of Science Education. Vol.9, 4: pp. 467-481.
- Johnston, J. (1997). Measuring affective attitudes in science: a comparison. Paper presented at the ESERA conference, Rome. Nottingham Trent University.
- Johnston, J. and Dunne, M. (1996). Revealing assumptions problematising research on gender, mathematics and science education. In Parker, L. Rennie, L. and Fraser, B. (Eds.) Gender, Science and mathematics: Shortening the Shadow. Dordrecht. Kluwer Academic Press.
- Jones, A.T. and Kirk, C.M. (1990). Gender differences in students' interests in applications of school physics. Physics Education. Vol. 25, pp.308-313.
- Kahle, J. B. (1985). Women and Science. Lewes. The Falmer Press.
- Kahle, J.B. (1987). Teachers and Students: Gender Differences in Science Classrooms. Contributions to the Fourth GASAT conference, volume 3 Michigan, U.S.A. Ann Arbor. (July, 1987).
- Kahle, J. B. and Lakes, M. (1983). The myth of Equality in Science Classrooms. Journal of Research in Science Teaching Vol. 20, pp.131-140.
- Kahle, J.B., Parker, L., Rennie, L., and Riley, D. (1993). Gender Differences in Science Education. Building a Model. Educational Psychology. Vol. 28, 4:pp. 379-404.
- Kelly, A. (1978). Girls and Science: An International Study of Sex Differences in School Science Achievement. Stockholm. Almqvist and Wiksell.
- Kelly, A. (1981). (Ed.) The Missing Half: Girls and Science Education. Manchester University Press.

- Kelly, A. (1981a). Sex Differences in Science Achievement: some results and hypotheses. In Kelly, A. (Ed.) The Missing Half: Girls and Science Education. Manchester University Press.
- Kelly, A. (1981). Science Achievement as an aspect of sex roles. In Kelly, A. (Ed.) The Missing Half: Girls and Science Education. Manchester University Press.
- Kelly, A. (1982). Why girls don't do science? New Scientist. Vol. 94, pp. 497-500.
- Kelly, A. (1987). (Ed.) Science for Girls? Milton Keynes. Open University Press.
- Kelly, A. (1987b). The Construction of Masculine Science. In Kelly, A. (Ed.) Science for Girls? Milton Keynes. Open University Press.
- Kenway, J. and Modra, H. (1992). Feminist Pedagogy and Emancipatory possibilities. In Luke, C. and Gore, J. (Eds.) Feminism and Critical Pedagogies. London. Routledge.
- Kenway, J. (1996). Reasserting Masculinity in Australian schools. Women's Studies International Forum. Vol. 19, 4:pp. 447-66.
- Keys, W. (1987). Aspects of Science Education in English Schools. (International Studies in Pupil Performance Series). Windsor. NFER Nelson.
- Keys, W. and Fernandes, C. (1993). What do students think about school? A report for the National Commission on Education. Slough. NFER.
- Keys, W., and Fernandes, C. (1994). What do students think about school? In Moon, B and Shelton Maves, A. (Eds.) Teaching and Learning in the Secondary School. London. Routledge.

- Keys, W. and Foxman, D. (1989). A World of Differences: an international assessment of maths and science. Windsor. NFER.
- Koballa, T.R. (1988). The determinants of female junior high school students' intentions to enrol in elective physical science courses in high school: Testing the applicability of the theory of reasoned action. Journal of Research in Science Teaching. Vol. 25, 6: pp. 555 – 564.
- Kreinberg, N. and Lewis, S. (1996). The Politics and Practice of Equity: Experiences from Both Sides of the Pacific. In Parker, L., Rennie, L. and Fraser, B. (Eds.) Gender, Science and mathematics: Shortening the Shadow. Dordrecht, Boston, London. Kluwer Academic Press.
- Kruse, A. -M. (1996). Single-sex Settings: Pedagogies for Girls and Boys in Danish Schools. In Gipps, C. and Murphy, P.F. (Eds.) Equity in the Classroom: Towards an effective pedagogy for girls. London. Falmer Press.
- Lather, P. (1995). Feminist Perspectives on Empowering Research Methodologies. Debates and Issues in Feminist Research and Pedagogy. Milton Keynes. Open University.
- LeCompte, M. and Preissle, J. (1993). Ethnography and Qualitative Design in Educational Research. London. Academic Press.
- Lee, V. and Bryk, A (1986). Effects of single-sex secondary schools on student achievement and attitudes. Journal of Educational Psychology. Vol. 78, 5: pp. 381-395.
- Levin, T., Sabar, N. and Linman, Z. (1987). Girls understanding of science-a problem of cognitive or affective readiness. Contributions to the Fourth International GASAT conference. Michigan U.S.A. Ann Arbour. (July, 1987).

- Lewis, A. (1992). Group child interviews as a research tool. British Educational Research Journal, Vol. 18, 4: pp. 413-421.
- Licht, B. and Dweck, C. (1987). Sex differences in achievement orientations. In Arnot, M. and Weiner, G. (Eds.) Gender and the Politics of Schooling. London. Hutchinson.
- Lie, S. and Bryhni, E. (1983). Girls and Physics: attitudes, experiences and underachievement. In contributions to the second GASAT conference. Oslo, Norway. (September, 1983).
- Maccoby, E. E. and Jacklin, C.N. (1974). The Psychology of Sex Differences. Paulo Alto, CA. Stanford University Press.
- Maccoby, E.E. and Jacklin, C.N. (1975). The Psychology of Sex Differences. Oxford University Press.
- Maccoby, E.E. and Jacklin, C.N. (1980). Psychological Sex Differences. In Rutter, M. (Ed.) Scientific Foundations of Developmental Psychiatry, Heinemann.
- Mahony, P. (1998). Girls will be girls and boys will be boys. In Epstein, D., Elwood, J., Hey, V. and Maw, J. (Eds.) Failing Boys? Issues in Gender and Achievement. Open University Press. Buckingham.
- Manis, M. (1985). Attitudes. The Social Science Encyclopedia. London. Routledge and Kegan Paul.
- Manthorpe, C. (1982). Men's science, women's science or science: some issues related to the study of girls' science education. Studies in Science Education, Vol. 9, pp.65-80.

- Manthorpe, C. (1985). The Value of an Historical Perspective on Girls and Science and Technology: the English Experience. In contributions to the Third GASAT Conference. University of London. (April, 1985).
- Manthorpe, C. (1989). Reflections on the Scientific Education of Girls. In Moon, B. and Murphy, P. (Eds.) Policies for the Curriculum. London. Hodder and Stoughton in association with the Open University.
- Mason, C., Kahle, J.B. and Gardner, A.. (1991). Draw a Scientist Test: Future Implications. School Science and Mathematics. Vol. 91:pp. 193-198.
- Mason, J. (1996) Qualitative researching. London. Sage.
- Matyas, M.L. (1985). Factors affecting female achievement and interest in science and scientific careers. In Kahle, J. (Ed.) Women in Science. Lewes. Falmer Press.
- McClintock Collective. (1989). A science teacher's collective. In Leder, G.C. and Sampson, S.N. (Eds.) Educating girls: practice and research. Sydney. Allen and Unwin.
- Mead, M. and Metraux, R. (1957). The image of the scientist among high school students: a pilot study. Science. Vol.126, pp.384-390.
- Merriam, S. B. (1991). Case study research in education: A qualitative approach. San Francisco. Jossey-Bass
- Millar, R. (1996). A science curriculum for public understanding. School Science Review. Vol. 77, 280: pp. p 7-18.

- Millar, R. (1997). Science education for democracy: What can the school curriculum achieve? In Levinson, R. and Thomas, J. (Eds.) Science Today. Problem or Crisis? London. Routledge.
- Millman, V. (1987). Teacher as researcher: a new tradition for research on gender. In Weiner, G. and Arnot, M. (Eds.) Gender under Scrutiny. New Inquiries in Education. London. Unwin Hyman.
- Mitroff, I. and Kilmann, R. (1978). Methodological Approaches to Social Science: Integrating Divergent Concepts and Theories. Jossey Bass.
- Morris, D. (1969) The Naked Ape. London. Corgi.
- Mortimore, P., Stoll, L., Lewis, D and Ecob, R. (1988). School Matters: the Junior Years. Wells. Open Books.
- MSC (1984). TVEI: Annual Review 1984. Sheffield. MSC.
- Mruk, C. (1999). Self Esteem. Research. theory and practice. London. Free Association Books.
- Munby, H. (1980). An evaluation of instruments which measure attitudes to science. In McFadden, C.P. (Ed.) World Trends in Science Education. Halifax, Nova Scotia. Atlantic Institute of Education.
- Murphy, P.F. (1989). Gender and Assessment in Science. In Murphy, P. and Moon, B, (Eds.) Developments in Learning and Assessment. London. Hodder and Stoughton.
- Murphy, P. F. (1991). Gender differences in pupils' reaction to practical work. In Woolnough. B. E. (Ed.) Practical Science. Buckingham. Open University Press.

Murphy, P.F. (1996). Defining Pedagogy. In Gipps, C. and Murphy, P.F. (Eds.) Equity in the classroom: Towards an effective pedagogy for girls and boys. London/Paris. Falmer/Unesco.

Murphy, P.F. (2000) Gender Identities and the Process of Negotiation in Social Interaction. In Joiner, R., Littleton, K., Faulkner, D. and Miell, D. (Eds.) Rethinking Collaborative Learning. London. Free Association Books.

Murphy, P.F. and Elwood, J. (1997). Gendered experiences, choices and achievement-exploring the links. Paper presented to the 23rd Annual IAEA Conference, June 9-13th 1997, Durban, South Africa.

Murphy, R.J.L. (1982). Sex Differences in Objective Test Performance. British Journal of Educational Psychology. Vol. 52:pp.213-219.

Office for Standards in Education and Equal Opportunities Commission (1996). The Gender Divide: Performance differences between boys and girls at school. London. HMSO.

Oleson, V. (1994). Feminisms and models of qualitative research. In Denzin, N. and Lincoln, Y. (Eds.) Handbook of Qualitative Research. Thousand Oaks. Sage.

Oliver, J.S. and Simpson, R.D. (1988). Influences of Attitude Towards Science on Achievement Motivation and Science. Self Concept on Achievement in Science. Science Education. Vol. 72, 2: pp.143-291.

Oppenheim, A.N. (1992). Questionnaire design, interviewing and attitude measurement. London. Pinter Publishers.

Ormerod, M.B. (1971). The social implications factor in attitudes to science. British Journal of Educational Psychology. Vol. 41: pp.331-338.

- Ormerod, M.B. (1975). Subject Preferences and Choice in Co-educational and Single Sex Secondary Schools. British Journal of Educational Psychology. Vol. 45: pp. 257-267.
- Ormerod, M.B. and Duckworth, D. (1975). Pupils' Attitudes to Science: a review of research. Windsor. NFER.
- Ormerod, M.B., Bottomley, J.M., Keys, W.P. and Wood, C. (1979). Girls and Physics Education. Physics Education. Vol. 14, pp.271-277.
- Orr, P. (1985). Sex bias in schools: national perspectives. In Whyte, J., Deem, R., Kant, L. and Cruickshank, M. (Eds.) Girl Friendly Schooling. London. Methuen.
- Osborne, J. (1997). Attitudes to Science. In Ogborn, J. (Ed.) Beyond 2000: Science Education for the Future. Report of Seminar 1. Nuffield Foundation Seminars.
- Osborne, J., Driver, R. and Simon, S. (1996). Attitudes to Science: a Review of Research and Proposals for Studies to Inform Policy Relating to Uptake of Science. London. King's College, London.
- Osler, A. (1997a). The Education and Careers of Black Teachers: Changing Identities. Changing Lives. Buckingham. Open University Press.
- Osler, A. (1997b). Exclusion from School and Racial Equality. London. Commission for Racial Equality.
- Parker, L.H. and Rennie, L.J. (1986). Sex stereotyped attitudes about science: Can they be changed? European Journal of Science Education. Vol. 8, 2: pp.173-83.
- Patton, M.Q. (1980). Qualitative Evaluation Methods. Beverley Hills, CA. Sage Publications.

Peltz, W.H. (1990). Can girls+science-stereotypes=success? The Science Teacher, Vol. 44, pp.49-50.

Piaget, J. (1953). Logic and Psychology. Manchester University Press.

Piburn, M. and Baker, D. (1993). If I were the teacher . . . a qualitative study of attitude toward science. Science Education, Vol. 77, 4: pp.393-406.

Postlethwaite, T.N. and Wiley, D.E. (1992). (Eds.) The IEA Study of Science 11: Science achievement in twenty three countries. Oxford. Pergamon Press.

Purvis, J. (1987). Social class, education and ideals of femininity in the nineteenth century. In Arnot, M. and Weiner, G. (Eds.) Gender and the Politics of Schooling. London. Hutchinson in association with the Open University.

Qualter, A. (1993). I would like to know more about that: a study of the interest shown by girls and boys in scientific topics. International Journal of Science Education, Vol. 15, No. 3 pp.307-317.

Ramsden, J.M. (1998). Mission Impossible? Can anything be done about attitudes to science? International Journal of Science Education, Vol. 20, 2: pp. 125-137.

Randall, G. J. (1987). Gender difference in pupil-teacher interactions in the workshop and laboratories. In Weiner, G. and Arnot, M. (Eds.) Gender under Scrutiny. New Inquiries in Education. Milton Keynes. Open University Press.

Raper, G. and Stringer, J. (1987). Encouraging Primary Science. Chatham. Cassell.

- Raphael Reed, L. (1998). Zero Tolerance: gender performance and school failure. In Epstein, D., Elwood, J., Hey, V. and Maw, J. (Eds.) Failing Boys? Issues in Gender and Achievement. Buckingham. Open University Press.
- Reiss, M. (2000). Understanding Science Lessons: Five Years of Science Teaching. Buckingham. Open University Press.
- Rennie, L., Parker, L. and Hutchinson, P. (1985). Teacher In-service as an Avenue to Equality in Science and Technology Education. In Contributions to the Third GASAT Conference England. Chelsea College, University of London. (April, 1985).
- Rennie, L. and Parker, L. (1987). Detecting and accounting for gender differences in mixed sex and single sex groupings in science lessons. Educational Review. Vol. 39, pp. 65-73.
- Rennie, L. and Punch, K. (1991). The relationship between affect and achievement in science. Journal of Research in Science Teaching. Vol. 28, 2: pp.193-209.
- Riddell, S. (1998). Boys and underachievement: the Scottish dimension. (Special Issue: Boys' Underachievement). International Journal of Inclusive Education. Vol. 2., Issue 2. pp.169-86.
- Rose, H. (1994). Love, Power and Knowledge: Towards a Feminist Transformation of the Sciences. Cambridge. Polity Press.
- Rosser, S. (1986). Teaching Science and Health from a Feminist Perspective. New York. Pergamon Press.
- Roth, M.W., McGinn, M. and Bowen, G. (1996) Applications of science and technology studies: Effecting Change in Science Education. Science, Technology and Human Values. Vol. 21, 4: pp.454-484.

- Royal Society (1992). Double Award GCSE Balanced Science: It's contribution to 'A' level success. Canterbury, Kent. Employment Department Group in conjunction with the Royal Society, SE information network, TVEI centre.
- Saraga, E. and Griffiths, D. (1981). Biological Inevitabilities or Political Choices: the future for Girls in Science. Manchester. Manchester University Press.
- Schibeci, R.A. (1984). Attitudes to Science: an update. Studies in Science Education Vol. 11, pp. 26-59.
- School Science Curriculum Review (SSCR) (1983) Science Education 11-18: Proposals for Action and Consultation. London. Royal Society.
- Simons, H. (1996). The paradox of case study. Cambridge Journal of Education. Vol. 26, 2: pp.225-240.
- Sjøberg, S. and Imsen, G. (1991). Gender and Science Education 1. In Fensham, P (Ed.) Developments and Dilemmas in Science Education. Falmer Press.
- Sjøberg, S. and Lie, S. (1981), Girls and Physics. In Contributions to the First International GASAT conference. Eindhoven University of Technology, The Netherlands. (September, 1981).
- Smail, B. (1984). Girl-Friendly Science: Avoiding Sex Bias in the Curriculum. York. Longman.
- Smail, B., Whyte, J. and Kelly, A. (1982). Girls into Science and Technology. School Science Review. Vol. 63, pp.620-630.
- Smail, B. and Kelly, A. (1984). Sex Differences in Science and Technology among 11 year old children. Research in Science and Technology Education. Vol. 2, pp.87-106.

- Smith, A.G. and Robbins, A.E. (1987). Teacher as researcher: a new tradition for research on gender. In Weiner, G. and Arnot, M. (Eds.) Gender under Scrutiny. New Inquiries in education. London. Unwin Hyman.
- Smithers, A. and Robinson, P. (1988) The Shortage of Mathematics and Physics Teachers. Manchester. Manchester University Press.
- Smithers, A. and Robinson, P. (1994). The Impact of Double Science. London. The Engineering Council.
- Solomon, J. (1993). Teaching Science, Technology and Society. Milton Keynes. Open University Press.
- Sørensen, H. (1985). Differences in girls and boys attitudes towards science-a study among 14 year old pupils in Hvidovre/Denmark with a view to developing strategies for change. In Contributions to the Third International GASAT conference. Chelsea College, University of London. (April, 1985).
- Sørensen, H. (1990). When girls do physics. In Contributions to the First European GASAT conference. Sweden, Jonkoping. (July, 1990).
- Spear, M., (1987). The biasing influence of pupil sex in a science marking exercise. In Kelly, A. (Ed) Science for Girls? Milton Keynes. Open University Press.
- Spender, D. (1982). Invisible Women. The Schooling Scandal. London. Chameleon books.
- Staberg, EM. (1994). Gender and Science in Swedish compulsory school. Gender and Education. Vol. 6. 1:pp. 35-45.
- Stables, A. and Wikely, F. (1996). Pupil approaches to Subject Option Choices. European Conference on Educational Research (ECER), Seville. (September, 1996).

- Stanworth, M. (1987). *Girls on the Margins: a study of gender divisions in the classroom*. In Weiner, G., and Arnot, M. (Eds.) Gender Under Scrutiny New Inquiries in Education. London. Unwin Hyman.
- Steinkampf, M.J. and Maehr, M.L. (1983). Affect, ability and science achievement: a quantitative synthesis of correlational research. Review of Educational Research, Vol. 53: pp. 369-396.
- Stenhouse, L. (1975). An Introduction to Curriculum Research and Development. London. Heinemann.
- Stobart, G., White, J., Hayden, M. and Mason, K. (1992) Differential performance at 16+: English and Mathematics. London. HMSO.
- Tamir, P. (1987). Israeli high school boys and girls achievement and attitudes towards science. In Contributions to the fourth GASAT conference, Michigan. USA. Ann Arbor. (Juky, 1987).
- Thomas, S., Pan, H. and Goldstein, H. (1994). Report on an analysis of 1992 examination results. London. Institute of Education.
- Thurstone, L.L. (1929). Attitudes can be measured. In M. Fishbein (Ed.) Readings in Attitude Theory and Measurement. New York. Wiley.
- Tiger, L. and Fox, R. (1974) Imperial Animal. London. Paladin.
- Tobin, K. (1988). Differential engagement of males and females in high school science. International Journal of Science Education. Vol. 10, 3: pp. 239-252.
- Trankina, M. (1993). Gender differences in attitude towards science. Psychological Reports. Vol. 73, pp.123-30.

- Tuckey, C. (1992). Who is a Scientist? Children's Drawings reveal all. Education. Vol. 3 - 13, 20: pp. 30-32.
- Turner, E., Riddell, S. and Brown, S. (1995). Gender Equality in Scottish Schools: the Impact of Recent Educational Reforms. Manchester. Equal Opportunities Commission.
- Versey, J. (1990). Taking action on gender issues in Science Education School Science Review. Vol. 71, 256: pp. 9 - 14.
- Vlaeminke, M., McKeon, F. and Comber, C. (1997). Breaking the Mould: an assessment of successful strategies for attracting girls into science, engineering and technology. London. Department of Trade and Industry.
- Vygotsky, L.S. (1962). Thought and Language. Cambridge, Mass. MIT Press.
- Vygotsky, L.S. (1978). Mind in Society. Cambridge, Mass. Harvard University Press.
- Walker, R. (1994). The conduct of educational case studies: ethics, theory and procedures. In Hammersley, M. (Ed.) Controversies in classroom research. Second Edition. Buckingham. Open University Press.
- Watts, M. (1983). A Study of Alternative Frameworks in School Science. Unpublished PhD Thesis. University of Surrey, Guildford.
- Watts, M. and Bentley, D. (1984). The personal; parameters of cognition: two aims in science education. Oxford Review of Education. Vol. 10, pp. 309-17.
- Watts, M. and Bentley, D. (1986). Methodological congruity in principle and practice: a dilemma in science education. Journal of Curriculum Studies. Vol. 18, 2: pp.167-75.

Watts, M. and Bentley, D. (1987). Courting the Positive Virtues: a Case for Feminist Science. In Kelly, A. (Ed.) Science for Girls? Milton Keynes. Open University Press.

Watts, M. and Bentley, D. (1989). Constructivism in the Classroom: enabling conceptual change by words and deeds. In Murphy, P. and Moon, B. (Eds.) Developments in Learning and Assessment. London. Hodder and Stoughton.

Watts, M. and Bentley, D. (1993) (Eds.) Learning and Teaching in School Science: practical alternatives. Milton Keynes. Open University Press.

Watts, M., Bentley, D. and Hornsby, J. (1993). Learning to make it your own. In Watts, M. and Bentley, D., (Eds.) Learning and Teaching in School Science: practical alternatives. Milton Keynes. Open University Press.

Weiner, G. (1994). Feminisms in Education. Buckingham. Open University Press.

Weiner, G. and Arnot, M. (1987). (Eds.) Gender and the Politics of Schooling. London. Hutchinson.

Weinreich Haste, H. (1981). The image of science. In Kelly, A. (Ed.) The Missing Half: Girls and Science Education. Manchester. Manchester University Press.

Whitelegg, E. (1992). Gender and Chemistry. In Attlay M., Bennet, S., Dutch, S., Levin, R., and Taylor, P. (Eds.) Open Chemistry. London. Hodder and Stoughton.

Whyte, J. (1983). Non-sexist teachers: evaluating what teachers can do to help girls opt into science and technology. In Contributions to the second GASAT conference. Oslo, Norway. (September, 1983).

- Whyte, J. (1983). Sexism in the Secondary Curriculum. London. Harper and Row.
- Whyte, J. (1986). Girls into Science and Technology: the story of a project. London. Routledge and Kegan Paul.
- Whyte, J., Deem, R. and Cruickshank, M. (1985) (Eds.) Girl Friendly Schooling. London. Methuen.
- Wilder, G.Z. and Powell, K. (1989). Sex Differences in Test Performance: a survey of the literature. New York. College Board Publications.
- Wilson, E.O. (1975). Sociobiology: a new synthesis. Cambridge. Harvard University Press.
- Willson, V.L. (1980). A meta analysis of the relationship between student attitude and achievement in secondary school science. Paper presented at the Annual meeting of the National Association for Research in Science Teaching, Anaheim, California. March 1980.
- Wood, D. (1988). How Children Think and Learn. Oxford. Blackwell.
- Woolgar, S. (1988). The Science of the Very Idea. London. Ellis, Horwood and Tavistock.
- Woolnough, B. E. (1991). The Making of Engineers. Oxford. OUDES.
- Woolnough, B. E. (1994). Why students choose physics, or reject it. Physics Education. Vol. 29, pp. 368-74.
- Wright, C. (1986). School Processes – an ethnographic study. In Eggleston, J., Dunn, D., Anjali, M. and Wright, C. (Eds.) Education for Some: Education and Vocational Experiences of 15-18 Year Old Young People of Minority Ethnic Groups. Stoke-on Trent. Trentham Books.

Zanna, M.P. and Rempel, J.K. (1988). Attitudes: a new look at an old concept. In Bar-Tal, D. and Kruglanski, A.W. (Eds.) The Social Psychology of Knowledge. Cambridge University Press.